ELEKTOR ELECTRONICS

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Focus on ISDN: Integrated Services Digital Network

COMPACT AF POWER AMPLIFIER

WIDEBAND mV METER

LONG-DISTANCE IrDA LINK

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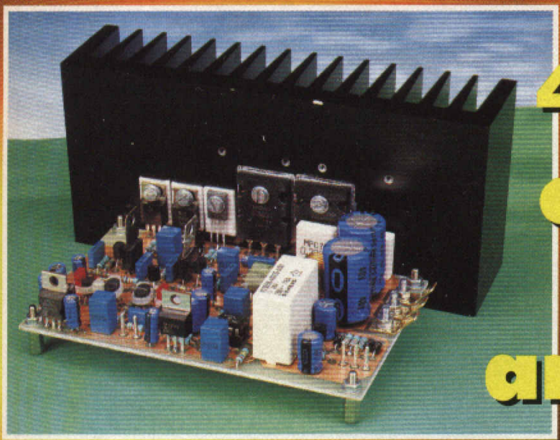

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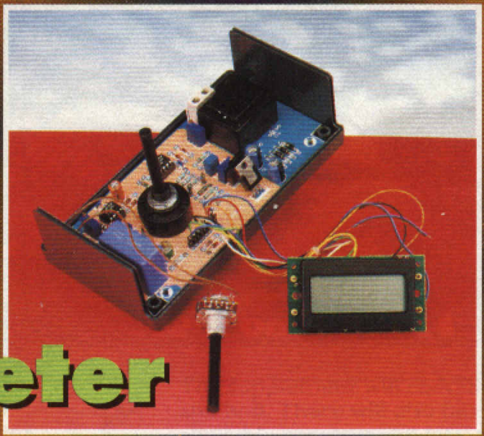

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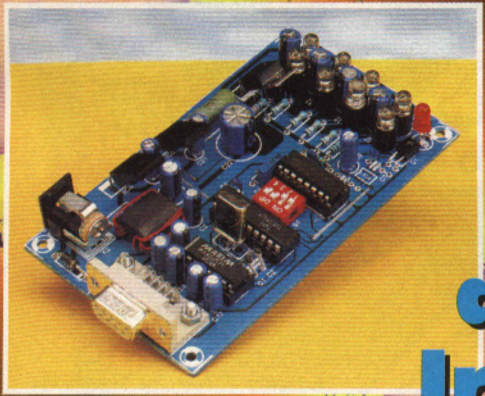

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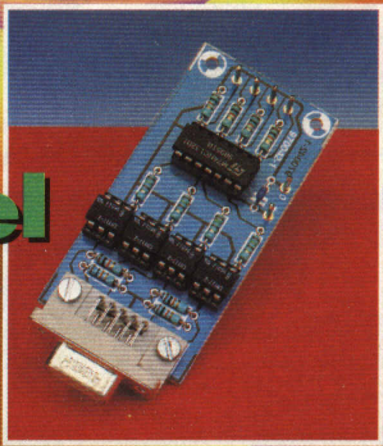

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DAB FOR ALL?

A new stage in the spread of DAB – digital audio broadcasting – has been marked by the inauguration in London of a World DAB Forum to succeed the European DAB Forum (EuroDab) founded in 1995. At least 20 countries, including Australia, Canada, China, India and many European nations, will have operational or pilot services running by the end of this year when the first consumer radio sets will be available. DAB will take radio into the multimedia age, offering text and data as well as near-CD quality sound.

The Forum brings together companies and organizations from all sectors of the broadcasting industry – including receiver and other equipment manufacturers, public and private broadcasters, transmission providers, regulators and satellite operators. The prime purpose is to help take the Eureka 147 system of DAB from the laboratory to the implementation stage and to work together to make it a commercial and consumer success.

It is estimated that in Europe more than 100 million people will be within reach of DAB by the end of this year. Most of the world's leading receiver manufacturers will be displaying DAB products at the major International Consumer Electronics Fair (IFA97) in Berlin in August/September.

DAB is a fundamental advance in radio technology, a bigger step than the introduction of FM, and one which will revolutionize radio in the way CD has transformer the music industry. It offers consumers interference-free reception, near-CD quality sound, easy-to-use sets, a wider choice of programmes, and text and data services as well as audio ones – in other words, multi-media radio. It is the first radio system designed to work equally well with fixed, portable and car radios.

The Eureka 147 system now being introduced in Europe, Canada and planned for other countries, as devised by a consortium of European broadcasters, research institutes and electronics companies. It is the only digital system to be fully specified and to meet the ITU's requirements for a world standard. The original Eureka Project members have since been joined by many others, and among the partners are such major manufacturers as Bosch/Blaupunkt, Clarion, Delco, Grundig, Kenwood, Panasonic, Philips, Pioneer and Sony.

ISDN IN EUROPE

ISDN – Integrated Services Digital Networks – is a transmission technology that has come to fruition rather belatedly in most of Europe. Fortunately, because broadband ISDN, which will almost certainly be based on ATM technology, is likely to be a largely compatible enhancement, the overall ISDN market will probably receive a second chance.

A good deal of credit for the development of ISDN should be given to the European Commission, which has for long been the prime mover in the liberalization of the European telecommunications market, a process that has led to the entry of many significant new companies in the arena.

At the same time, the established national telecommunications administrations have been obliged to become more efficient by reducing costs and bureaucracy, and becoming much closer to the user. As ISDN coverage and subscriptions expand, it will, no doubt, become the de facto standard for many types of new terminal, and for carrying new types of communications service.

There are three dimensions of market growth in the ISDN industry: the growth in ISDN networks and the number of subscribers, the expansion in the use of terminal equipment and adaptors connected to these networks, and the range of new digital services that offer much enhanced functionality compared with those available using analogue circuits. These three factors are very closely associated and, indeed, they cascade down from one to the other.

It is unfortunate that most national Telecommunications Administrations have had somewhat equivocal feelings towards ISDN, while they have been generally quite unprepared to promote the types of application that are needed to drive it. Instead, they have typically allowed the market to dictate development without themselves providing very much of a lead.

This serious failing could well be exploited by the new fixed-network operators that are due to start operations in most European countries from the start of 1998. They will certainly offer ISDN, but the more strongly financed organizations could well take more imaginative strategies prior to the availability of broadband ISDN, and this trend would adversely affect the ISDN market, certainly for major users of higher bandwidth.

Nevertheless, several basic demographic and cultural developments are coming to the aid of ISDN, which should provide a strong market pull in the coming years. The Internet, for example, cries out for the usage of ISDN access, while the strong move in many countries towards home- or tele-working is rapidly expanding the demand for faster and higher quality, but still narrowband, communications facilities to be available on a modest cost dial-up basis.

(Anyone seriously interested in western European telecommunications should note that the *Financial Times* has published a report entitled 'Liberalizing Telecoms in Western Europe. This report provides you with 17 country profiles – the 15 EU countries plus Norway and Switzerland. Each profile gives you a detailed analysis of the state of liberalization, its impact on both established and new operators, and the prospects for the future in each country. Phone 0171 896 2235 or fax 0171 896 2234 for more details).

EUROPEAN SPACE AGENCY AIMS FOR HIGH TECH MARKET IN SPACE

(By Dr C R Lavers)

The last two years have seen the development of the European Space Agency's RADIUS Programme (Research Associations for the Industrial Use of Space), which has been established to create a commercial market for private sector utilization of the International (formerly Alpha/Freedom) Space Station.

The RADIUS Programme offers industrial custo,mers the possible commercial benefits of materials fabrication and processing in a microgravity environment. Companies interested in such

work have so far come from areas involving biotechnology, pharmaceuticals, electronics, optoelectronics and metallurgy. Several areas such as the crystallization of proteins and the purification of macromolecules, based in France, and the growth of semiconductor and electro-optic materials, based at Freiburg University in Germany have already been tested in space. The Advanced Protein Crystallization Facility (APCF) has flown on several Shuttle missions, and has allowed optimization of crystal growth parameters, and included three different methods of crystal fabrication.

A study of fluid physics and dispersion, based at the Microgravity Research Centre at the University of Leuven, in conjunction with data from orbital flights has helped their customer, the French oil company Elf Aquitaine, to determine the optimum position of drilling sites and the most effective method of crude extraction .

The next proposal is a French health investigation of osteoporosis, wound healing and the study of cancers which will have potential benefits for the pharmacological industries.

The RADIUS Programme is to be incorporated into ESA's Manned Space Flight and Microgravity Programme to guarantee participants access to space and also the International Space Stations which will start to be assembled from later this year onwards.

REVISED RADIO AMATEURS' EXAMINATIONS

City & Guilds have announced that it is to simplify the format of the Radio Amateurs' Examination (RAE) from May 1998.

Following a request from the Radio Society of Great Britain, the national representative organization for Radio Amateurs in the UK, it has been agreed that the revision will start in May 1998.

Currently, the examination is taken in two parts, at a cost of £19·40 per paper (£38·80 for the complete examination). From May 1998, the two papers will be amalgamated into one paper of 30 multiple choice questions. The cost for the revised examination will be reduced to £26. Candidates who have passed one paper of the current RAE will be able to continue to carry over that pass until May 1998 when they will need to resit the full new examination. A pass is required in the examination to obtain a Radio Amateur Licence. The RAE is conducted at approved examination centres throughout the UK in May and December every year.

It is hoped that this change will encourage more people to take up Amateur Radio in the future.

For further information about the new course, contact the City & Guilds Customer Services Enquiries Unit at 1 Giltspur Street, London EC1A 9DD, phone 0171 294 2801/2805/2797.

INTERNET PROBLEMS

All existing telephone lines are too slow and therefore not suitable for serious work on the Internet.

Control of the contents of data on the Internet is virtually impossible.

All software now in use is wholly or partly not suitable for serious work on the Internet.

There is (as yet) no good, safe and internationally suitable system for making payments for goods or services via the Internet.

All PCs now in use are much too slow for serious work on the Internet.

Virtually all existing cable networks are intended for unidirectional transmissions. They must be converted for bi-directional traffic.

Copyright control is very complex and in many cases impossible.

The levying of VAT and other local sales taxes on goods sold via the Internet is almost certainly impossible.

All modems now in use are too slow for serious work on the Internet.

JAVAOS™ ON ARM RISC

Advanced RISC Machines (ARM) and Sun Microsystems, Inc's JavaSoft business unit have collaborated to enable the JavaOS™ operating system to run on the ARM RISC architecture. The ARM version of JavaOS is now directly available from JavaSoft. JavaSoft will license JavaOS for the ARM architectures and provide technical support directly to licensees electing that platform.

JavaOS is a highly compact, dynamically extensible operating system designed to run Java™ applications directly on microprocessors in anything from network computers (NCs), PDAs, mobile phones, printers and set-top boxes, to countless other devices. JavaOS is one of the smallest and fastest implementations of the Java platform available. In addition to the ARM processors, JavaOS runs on X86 and SPARC™ processors.

ARM's strong semiconductor partnership and high-performance, power-efficient technology will enable Sun to build upon its current Java base in the network computing market and offer affordable, user-friendly consumer information appliances.

ARM is one of the leading architectures in the growing market of NCs: Wyse Technology's ARM-based Winterm 4000 Enhanced Network Computer (ENC) won BYTE Magazine's Best of Comdex award for Best System. Additional ARM-based NCs and Internet appliances include the Acorn Office NC, the AlphaVision Kisun Internet Terminal, the Boundless Technology NC, the Daewoo/Teknema Internet TV set-top box, the Oracle NC, the Teknema EasyRider and the Viewcall Netsurfer.

The StrongARM SA-110 microprocessor, co-developed by ARM and Digital Semiconductor, has the highest published scores for the CaffeineMark 2.01 interpreted Java applet performance benchmark, in comparison to other well-known desktop systems.The StrongARM results were obtained with a prototype Internet terminal, a reference hardware design for the StrongARM SA-110 chip that was used by Digital to port the JavaOS operating system to the StrongARM architecture.

The ARM architecture is an ideal solution for cost- and power-sensitive markets. The ARM family includes the ARM7TDMI 'Thumb™', which reduces system cost with its excellent code density, the ARM7500 and ARM7500FE, which provide highly-integrated system solutions for Internet appliances, and the ARM810 and StrongARM processor, which enable supercomputer performance from two AA batteries.

ARM is the leader in microprocessor Intellectual Property. ARM designs and licenses fast, low-cost, power-efficient RISC processors, peripherals and 'system-chip' solutions for embedded control, consumer/educational multimedia, DSP and portable applications. ARM supports its processor offering with Development Hardware and Software and contract Design Services. ARM licenses its technology to leading semiconductor, software, and OEM partners worldwide who focus on applications, design and manufacturing. Each partner offers unique ARM-related technologies and services which together satisfy a broad range of end-user needs. Through this partnering, ARM is rapidly becoming the global volume RISC standard.

ARM's semiconductor partners include: AKM, Alcatel Mietec, Atmel ES2, Cir-

rus, Digital, GEC Plessey Semiconductors, LG Semicon, NEC, Oki, Samsung, Sharp, Symbios Logic, TI, VLSI, and Yamaha.

ARM also partners with leading Operating System, Development Tool, Design and OEM companies from around the world.

RED PLANET STILL ESCAPES LEGACY OF RED EMPIRE

(By Dr C R Lavers)

The failure of the Mars 96 orbiter launch on 16 November last year from Baikonur cosmodrome in Kazakhstan will be remembered as a significant set-back to the ailing Russian Space Agency. The agency has suffered a severe lack of funding in the aftermath of the collapse of the former Soviet Union. Space scientists have experienced a fall in both real income and in research funds. Many of the scientists working on the project were unpaid – hoping against the odds that the mission would succeed in spite of an inability even to carry out vital pre-flight tests. The desperation to launch was nothing short of Scientific Russian Roulette, which in this case resulted in a final burn-up somewhere over the Pacific Ocean caused by a failure in the fourth series of booster rockets. Without a successful final stage boost it was not possible for the Orbiter to gain the necessary velocity to escape the Earth's gravitational field.

What makes this failure tragic is that it was almost certain to fail; the previous ten missions attempted since 1962 resulted in seven total failures: the other three have delivered the bare minima of technical data. Only a couple of weeks before the launch, Vasily Moroz, a senior scientist on the project, explained that funds no longer existed to carry out vital tests on two of the four landing craft that the Orbiter was to dispatch, and that tests would have to take place throughout the duration of the flight, with any software modifications to take place as necessary.

The result is that the Russians, although having nearly four decades experience of powerful space rocket design, will not be in a position to mount further launches to the Red Planet in the foreseeable future. The disaster is not only one for the Russians, but for the Europeans as well: twenty European countries, in addition to the USA, had a significant amount of electronic hardware on board the six-tonne craft costing £40 million. Some of the European equipment had taken the best part of a decade to design, and replacement in the short term is impossible. Following in the wake of the Cluster mission destruction on ESA's new Ariane V rocket, the immediate prestige of European space missions has been severely dented.

The result of these catastrophes is that NASA has the field completely free of competition for any Martian missions well into the next decade. The track record for NASA is more encouraging since the failure of the first Mars Observer upon entering Martian orbit a couple of years ago. On 4th July this year, the Mars Pathfinder (assuming a more successful launch than the Mars 96 probe) will descend on to an ancient Martian flood plain and will signal the first US return to the Red Planet since the Viking missions back in the seventies which broadcast stunning information for a couple of years. It will deploy a small rover to explore the region around the lander and will photograph the terrain in a range of spectral energies. The overall aim is quite simple: to establish whether a low-cost soft landing is possible. This will be followed in September this year by the Mars Global Surveyor, which will relay information obtained from the Mars Pathfinder. The Mars Global Surveyor will enter into orbit around Mars by 'aerobraking', that is, using friction with the planet's tenuous atmosphere to decelerate it. It will scan the surface from a height of 400 miles and give a resolution of one metre.

The Americans intend to send a pair of spacecraft to Mars every 26 months until 2005, with a possible sample-return mission launched as early as 2003. A lander would deploy a robotic rover to collect geological specimens and a return rocket may insert the samples into an Earth orbit for possible analysis on the International Space Station. The European nations would be wise to consider future partnerships with NASA if they wish to maintain a stake in the action. Apart from Japan no other country has the technological expertise, the willpower, and the money, to reach out and, hopefully, land safely on the Red Planet.

MCS251 μCOMPUTER IN A MATCHBOX

Based on the latest SMD and multilayer technology, **microMODULE8** from Phytec represents the latest in subminiature microcontroller boards. Equipped with the Intel MCS8XC251 8-bit controller, the **microMODULE8** is a computer in matchbox (51×36×8 mm) format. This can be treated rather like a 'big chip' on a larger application board.

The MCS251 family microcontroller can be run in a downwards compatible mode to the 8051. This means that existing 8051 software can be run on the **microMODULE8** without any changes having to be made. With the same crystal frequency, the existing 8051 code is executed up to 5× quicker. Application programs that use the MCS251 code, running in the 'source mode' of the controller, are up to 15× quicker.

In addition, the MCS251 controller on the **microMODULE8** can run in the page mode. The speed advantage gained from this is useful and arises from the fact that during a page hit no further high address lines are placed on the multiplexed bus.

Various forms of the 251 currently exist: Step A to Step C. The latest Step C controller operates in the 18 address-line mode. This means that the external addressing totals 257 Kbytes. Flexible address decoding allows for the easy partitioning of the address space. When connecting external peripherals, three additional chip select signals are available.

The **microMODULE8's** clock frequencies are up to 16 MHz, allowing for a higher data throughput. The memory consists of up to 512 Kb SRAM and 512 Kb flash EPROM, sufficient for complex applications.

The on-board programming of the flash EPROMs via the serial interface to the RS232 allows for the simple configuring of the memory, the downloading of the application programs, as well as in-the-field software updates.

The serial interface can alternative be configures to either RS232 or RS485. In order to function, the **microMODULE8** only requires a regulated 5 V supply. Its current drain is about 120 mA in the temperature range of 0 °C to +70 °C.

Powerful MCS251 development tools, i.e., C compiler, assembler and debugger, are also available from Hitex (see p. 8) for software development. During preliminary stages, or when dealing with small applications, an efficient monitor debugger is available.

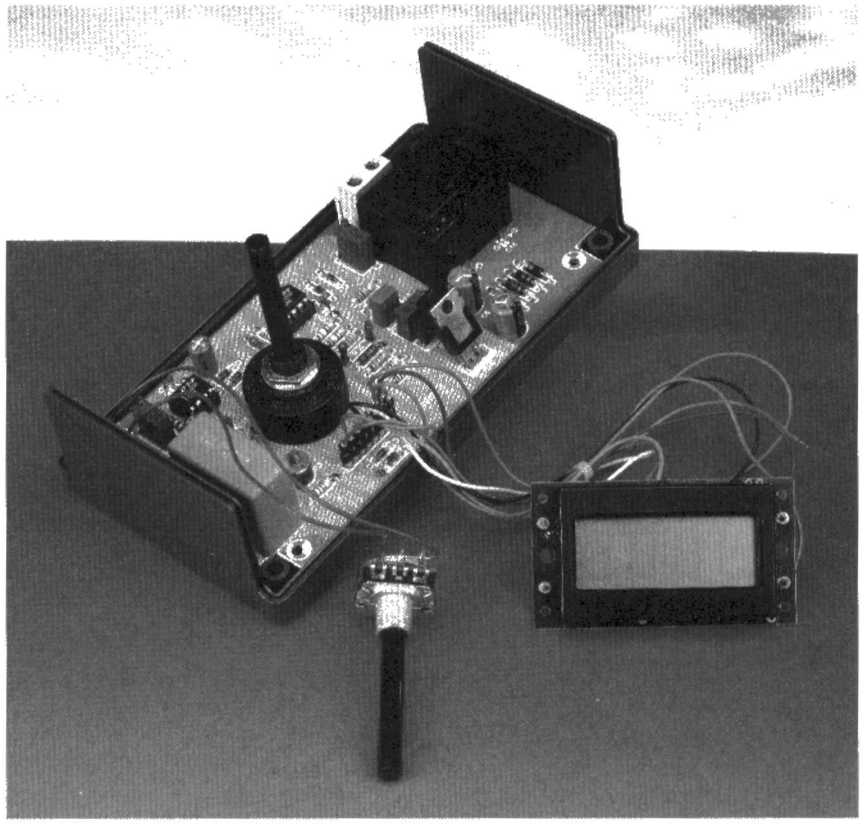
The standard **microMODULE8** comes ready-assembled and tested. It is fitted with 128 Kb SRAM and 128 Kb flash EPROM, all necessary documentation, embedded pin/socket boards, and a utility disk with flash programming tools.

The price of the standard **microMODULE8** is £125.

wide-band millivoltmeter

accurate measurements with simple means

High-frequency signals cannot be measured with standard voltmeters or multimeters. Such voltages, which are commonplace in receivers, transmitters and other high-frequency equipment, can only be measured with a special, wide-band millivoltmeter. Commercial versions of this kind of instrument tend to be expensive. This article shows that if certain limitations are acceptable, it is possible to construct a suitable instrument with modest means.



Design by F. Hueber

Standard operational amplifiers are not suitable for use in test circuits owing to their frequency limiting properties. Even special op amps can operate over a frequency range of only a few hundred kilohertz. It is for this reason that in wide-band instruments the circuits are often designed with discrete r.f. transistors. These transistors provide only small amplification and low-impedance circuits, require good shielding, and are fairly expensive.

A possible alternative is the use of an r.f. rectifier probe followed by a d.c. amplifier, but this design may experience stability problems. Also, owing to the curvature of the operating characteristic of the rectifier, the frequency range is too narrow for a reasonable quality millivoltmeter.

A better idea is the use of op amps with current feedback which have been available for several years and which can be used in r.f. circuits. In fact, they are used as video amplifiers in television receivers, as antenna amplifiers, and in a score of other types of r.f. circuit. Thanks to the vast production quantities, the price of these devices is also very reasonable. All in all, these op amps are eminently suitable for use as instrument amplifier and rectifier in a millivoltmeter.

It is, of course, possible to measure r.f. signals with an oscilloscope, but not as accurately and conveniently as with a millivoltmeter with digital display.

Brief specification

Frequency range	*30 Hz – 3 MHz (±0.2 dB, ±1 digit)*
	<<10 Hz – 15 MHz (–3 dB)
Measurement ranges	*200 mV, 2 V, 20 V*
Lower measurement limit	*about 10 mV*
Input impedance	*50 Ω shunted by 15 pF*
	(may be switched to 20 kΩ)
Display	*3.5 digit liquid crystal*
Power supply	*240 V, 1.5 VA*

The block diagram of the millivoltmeter based on an op amp with current feedback as described in this article is shown in **Figure 1**. Note that a data sheet of the op amp is given elsewhere in this issue.

Since it assumed that in the vast majority of circuits to be tested with the present instrument the highest r.f. voltages will not exceed 20 V, this level is chosen as the upper input level. This greatly simplifies the design of the input stage, since a linear input voltage divider would need a number of expensive high-tolerance capacitors.

ance at the non-inverting input of IC_1. This is important since this IC, in common with virtually all r.f. op amps, requires a fairly high input current. (A varying source impedance would result in constantly changing input offset voltage). The present design ensures an input impedance of 22 kΩ, which is a reasonable compromise between the requirements of r.f. and l.f. measurement techniques.

The three voltage ranges, 200 mV, 2 V and 20 V, are selected with switch S_2. In the two lower ranges, the input signal is applied directly to the input of the op amp, but in the higher range

Circuit IC_1 is arranged as a standard ×2.5 amplifier, whose offset is compensated with preset P_2. Since the operation of this type of op amp is strongly dependent on the ambient temperature, preset P_1 provides additional fine compensation of the offset voltage. Resistor R_7 increases the output load of IC_1. This resistor is recommended by the manufacturer of IC_1 to obtain a large bandwidth.

Circuit IC_2 is arranged as a classical half-wave rectifier (with offset compensation if required). Networks R_{11}-D_3 and R_{12}-D_4 form a constant load for the two half waves at the out-

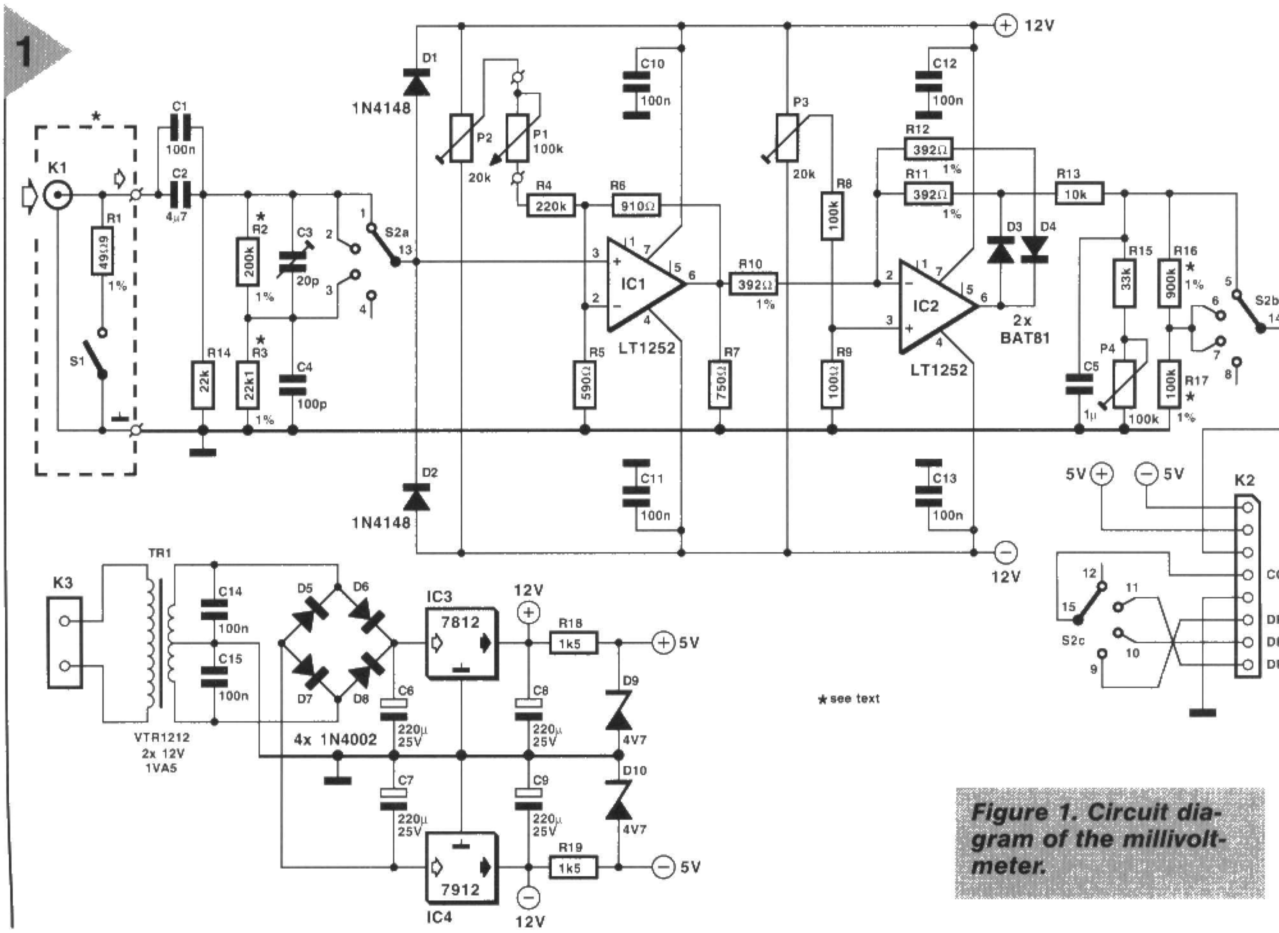


Figure 1. Circuit diagram of the millivoltmeter.

CIRCUIT DESCRIPTION

The r.f. component of the signal to be measured (the measurand) is applied via input socket K_1 to a potential divider. The value of coupling capacitor C_2 is fairly high to ensure that even low-frequency signals are passed without loss. Since large-value foil capacitors do not have good r.f. properties, C_2 is shunted by a ceramic capacitor, C_1. To ensure a stable 50 Ω input impedance, R_1 may be switched into circuit with S_1.

The potential divider consists of resistors R_2, R_3, and R_{14}, and compensating capacitors C_3 and C_4. The divider ensures a stable source imped-

it is first divided by ten.

Diodes D_1 and D_2 are the usual limiting devices that short-circuit too high or too low input signals to the supply line. The use of a resistor as current limiter is not possible since it would form a high-pass filter with the input capacitance, which would narrow the usable frequency range. It should, therefore, be noted that although the instrument is a.c. coupled, it can cause a short-circuit when the signal level or the signal frequency is too high.

Diodes D_9 and D_{10} are protection devices against too high or too low supply voltages.

put of IC_2. These diodes cannot be standard 1N4148 or BAT85 types, but must be suitable for use in r.f. circuits with very low capacitance, C_D, and very low recovery time, t_{rr}. In the present design, the BAT81 is used (C_D <<1.6 pF and t_{rr}<<1 ns).

It is not only the peak voltage, U_F, (about 500 mV) that plays a role in the limiting of the voltage level in linear rectification, but also the ×1000 amplification of the op amp. The theoretical minimum level is U_F/α_L = 500 µV. Owing to the effect of output offsets and various non-linearities, this figure reduces by a factor 10 and even a little more at the extremes of the frequency range. In general, however, it may be

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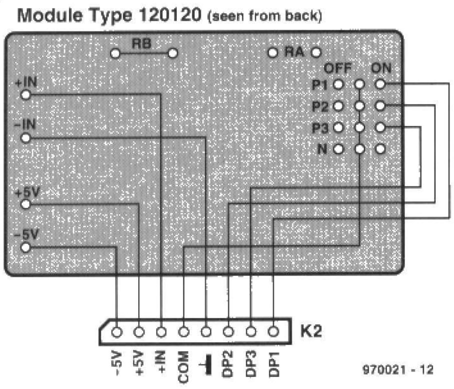


Figure 2. How to connect the millivoltmeter board to a commercial voltmeter module.

assumed that the output is linear with input signals of 10 mV and higher.

The half-waves at the output of IC_2 are rendered into a smooth direct voltage by integrator R_{13}-C_5.

Precise calibration is afforded by making the potential divider variable (R_{13}-R_{15}-P_4).

In the 2 V and 20 V ranges, resistors R_{16} and R_{17} divide the voltage by 10, so that the output of the millivoltmeter is a direct voltage of 0–200 mV. The three display ranges are distinguished by S_{2c} switching the decimal point as appropriate.

The rectifier is intended for use with sinusoidal signals and produces the average value of these. When a square-wave signal is being measured, the display shows a value that is 11% too high (form factor = 1.11).

The power lines are provided by an integrated mains supply that uses a short-circuit-proof mains transformer. The secondary voltage of the transformer is rectified and stabilized to ±12 V by two regulators. The ±5 V power lines for the display module are stabilized by D_9-R_{18} and D_{10}-R_{19}.

DISPLAY

The millivoltmeter may be built as a stand-alone unit or as an adaptor for a digital multimeter (DMM). In the latter case, the earth and the test output circuit of the instrument are linked via a suitable cable to the DMM, which should be set to its 200 mV direct voltage range. Mind the decimal point!

Connecting the instrument to a liquid-crystal-display (LCD) module is rather more complicated since the circuit and the board layout are not uniform. The most frequently encountered (and least expensive) module uses an analogue-to-digital converter (ADC) Type 7106 and needs only a simple 9 V supply line (such as a PP3 battery).

The –ve terminal of the battery (–BAT) must NOT be linked to the signal earth line (IN LO), even when the module internally generates the requisite negative (w.r.t. the signal earth) voltage.

When all these points are found in order, the LCD module may be connected to the millivoltmeter board via terminals K_2 as shown in **Figure 2**. Modules that are provided with range resistors should be wired permanently in the 200 mV mode.

Next, link up the four wires via which the decimal point is controlled. The decimal-point terminals are not the same in all cases: often, their sequence is not uniform. So, it is vital to consult the connection diagram of the display module when connecting decimal-point switch S_{2c}.

CONSTRUCTION

Since the instrument is intended for measuring signals at frequencies up to 15 MHz, it is best built on the double-sided, through-plated board shown in **Figure 3**. The construction is not particularly difficult. During soldering, it is advisable to place a strip of cardboard under the component being worked on to avoid it touching the ground plane.

Of all the components, only potential dividers R_2-R_3 and R_{16}-R_{17} should be soldered on to PCB pins.

Do not yet solder IC_1 and IC_2 into place.

When all components (except IC_1 and IC_2) have been soldered into place, carefully check their polarity and position where relevant and inspect the board for dry joints and any blobs of solder that may later cause adjacent tracks to be short-circuited.

Set all potentiometers to the centre of their travel, connect the mains voltage and check the following voltages:
across C_6 and C_7: about ±17 V;
at pins 4 and 7 of IC_1 and IC_2: ±12 V;
at pins 7 and 8 of K_2: about 4.7 V.

If these potentials are found all right, disconnect the mains and solder the ICs into place.

Fit the board and display module into the case, and wire up all parts, including the BNC socket, potentiometer P_1 and the range switch.

Reconnect the mains voltage and check that the display reads 'something'; set the decimal point with the range switch.

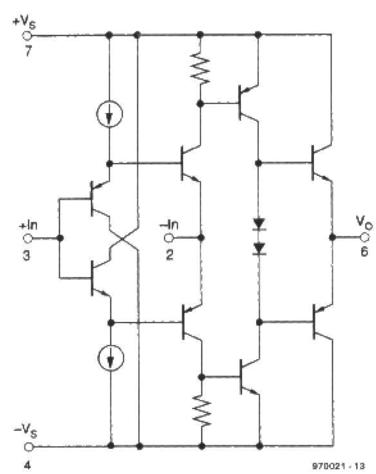
CALIBRATION

Leave the instrument on for about 15–20 minutes to enable it to reach its normal operating temperature. (It is good practice in later use also to let the instrument warm up for about five minutes before making any measurements).

1. With open input, S_1 open, P_1 at the centre of its travel, and S_2 in the 200 mV range, measure the offset voltage at pin 6 of IC_1 with a digital multimeter (DMM) set to its 200 mV a.c. range and adjust P_2 until the DMM shows 000.0 mV. Disconnect the DMM and adjust P_3 until the millivoltmeter display also reads 000.0 mV.
2. To set the sensitivity, reconnect the DMM to pin 6 of IC_1 and apply a 300 Hz sinusoidal signal at a level of around 190 mV to the input. Adjust P_4 until the display shows the same value as the DMM.
3. To check the precision of the potential divider, leave the signal generator connected to the input (300 Hz at 190 mV) and set the range switch to 2 V, whereupon the display should read 0.190. Connect a low-value resis-

Current feedback

Operational amplifiers (op amps) with current feedback are outwardly indistinguishable from those with voltage feedback. In these types of op amp, the current through the feedback loop determines the performance. This is because the inverting (–ve) input is not connected to a high-impedance differential amplifier, as in a standard op amp, but to a low-impedance emitter follower. Therefore, such an op amp, such as the LT1252, is eminently suitable for driving low-impedance (and capacitive) loads such as a coaxial cable. In fact, it can be used in all applications that require a large stable bandwidth that is independent of the amplification factor, a high slew rate, and good linear transfer.



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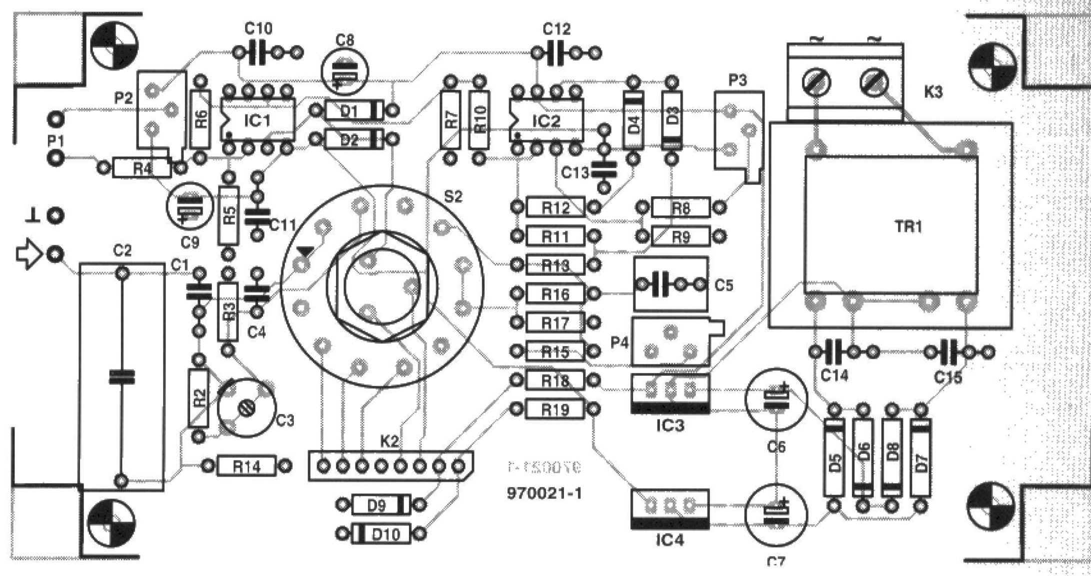
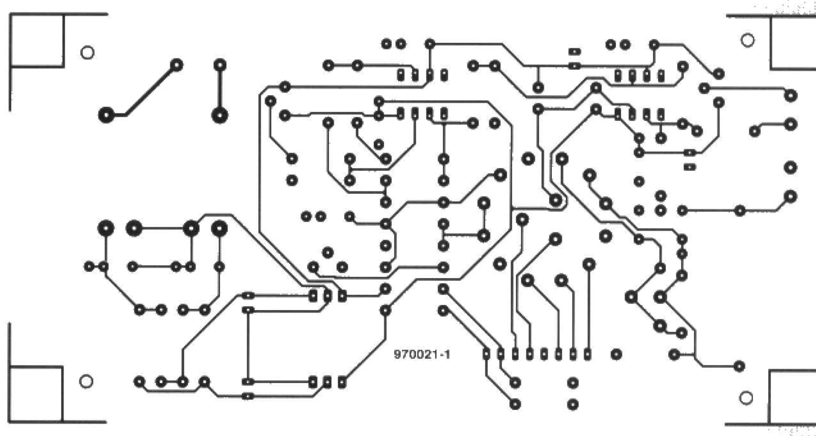
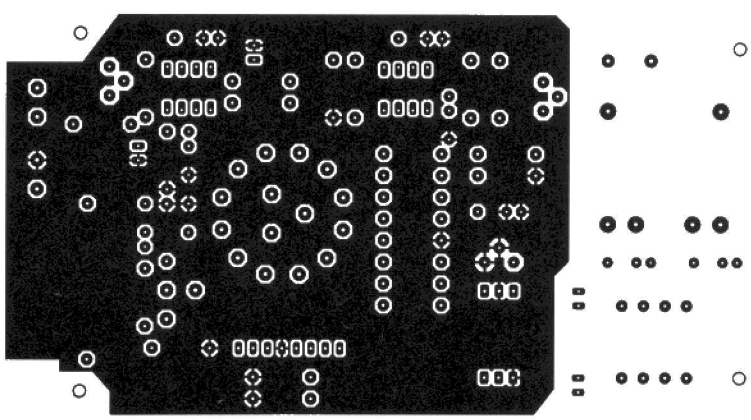






Parts list

Resistors:
R_1 = 49.9 Ω, 1%
R_2 = 200 kΩ, 1%
R_3 = 22.1 kΩ, 1%
R_4 = 220 kΩ
R_5 = 590 Ω
R_6 = 910 Ω
R_7 = 750 Ω
R_8 = 100 kΩ
R_9 = 100 Ω
R_{10}–R_{12} = 392 Ω, 1%
R_{13} = 10 kΩ
R_{14} = 22 kΩ
R_{15} = 33 kΩ
R_{16} = 900 kΩ, 1%
R_{17} = 100 kΩ, 1%
R_{18}, R_{19} = 1.5 kΩ
P_1 = potentiometer, 100 kΩ, linear
P_2, P_3 = multiturn preset, 20 kΩ, radial
P_4 = multiturn preset, 100 kΩ, radial

Capacitors:
C_1, C_{10}–C_{15} = 100 nF, ceramic
C_2 = 4.7 μF foil
C_3 = trimmer, 20 pF
C_4 = 100 pF
C_5 = 1 μF, foil
C_6, C_7 = 220 μF, 25 V, radial
C_8, C_9 = 47 μF, 16 V, radial

Semiconductors:
D_1, D_2 = 1N4148
D_3, D_4 = BAT81
D_5–D_8 = 1N4001
D_9, D_{10} = 4.7 V zener, 500 mW

Integrated circuits:
IC_1, IC_2 = LT1252 (Linear Technology)
IC_3 = 7812
IC_4 = 7912

Miscellaneous:
K_1 = BNC socket, chassis mounting
K_2 = PCB mounting 8-way pin header
K_3 = 2-way PCB terminal block with screw clamps, pitch 7.5 mm
S_1 = single on switch
S_2 = 3-pole, 4-position rotary switch
Tr_1 = mains transformer, secondary 2 × 12 V, 1.5 VA, short-circuit-proof, e.g. Velleman 2120018M (from Maplin)
Case 150×80×55 mm (Bopla E440 or OKW A9032065)
3.5 digit voltmeter module (200 mV)
PCB Order no. 970021

Figure 3. All components, including the mains transformer, fit neatly on the printed-circuit board.

tor in series with R_{17} if the reading is smaller or in series with R_{16} if it is larger.

4. Repeat the same procedure as in 3., but increase the signal generator output to 1.9 V and set the range switch first to 2 V and then to 20 V. The relevant resistors are then R_2 and R_3.

5. Reduce the output of the signal generator to 190.0 mV and check that the setting of P_4 still gives the required sensitivity. Readjust the control as in 2. if necessary

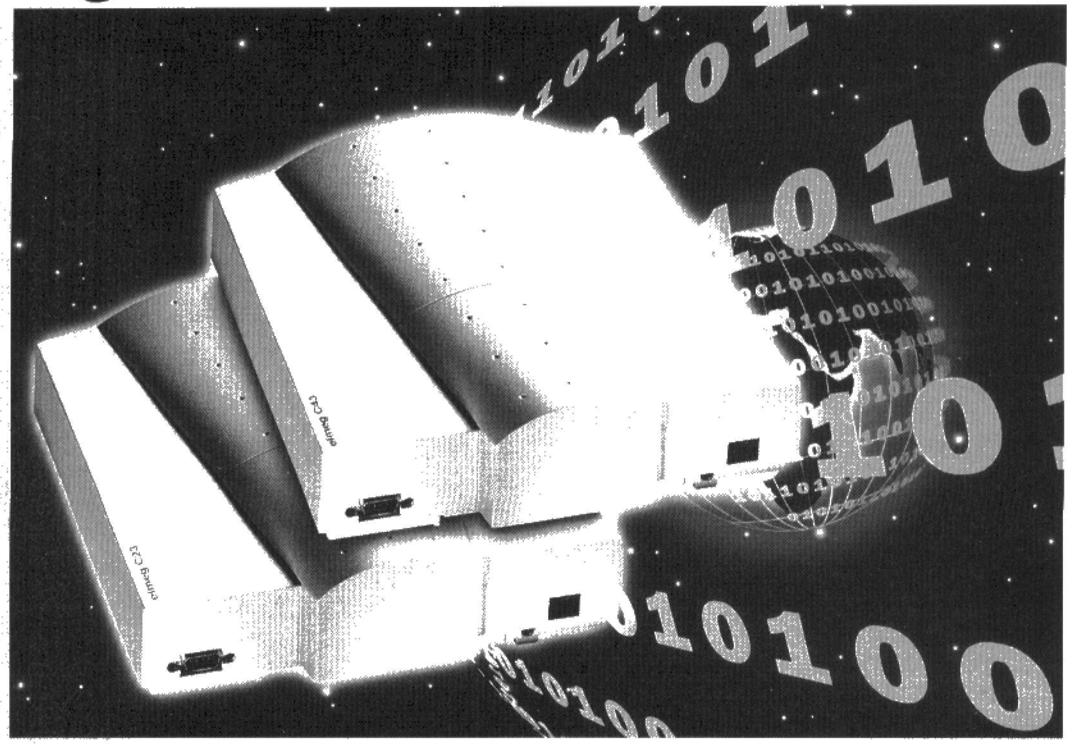
6. To set trimmer capacitor C_3 as necessary, set the range switch to 2 V and the signal generator output to a level of 1.9 V and its frequency to >300 Hz. Note the display reading. Then, set the range switch to 20 V, whereupon the display reading should remain the same. If not, correct it by adjusting C_3 as appropriate.

This completes the calibration: the millivoltmeter is now ready for use.

[970021]

focus on: ISDN

digital communication lines



photograph courtesy Elmeg

Some of the most likely causes for the increased demand for ISDN connections are the wider acceptance of fax machines for private use, the need to have several telephone lines available, *and, of course, the* widespread use of the Internet as a global medium. What is ISDN, what does the system offer, and for whom is it useful? In this article we examine the history and technical features of an ISDN connection.

By our editorial staff

ISDN (Integrated Services Digital Network) is an advanced, but by not necessarily new, set of telecommunication services based on a digital version of the existing telephone networks (PSTN, public switched telephone network). Instead of analogue signals, which have been used ever since the invention of the telephone, the ISDN system employs digital datastreams which may, in principle, be conveyed via available PSTN links. Because the data format is the only elementary factor in a digital system, ISDN offers far more applications than just voice calls. The term *data format* covers, among others, the structure of the data block and the associated control signals. Since nearly all digital information may be translated or converted into a uniform format, ISDN is a good choice when it comes to distributing digitised audio, video and high-speed data. The main condition for this to be realised is that sufficient bandwidth is available. The advantages of digital as opposed to analogue communication are obvious: improved speech quality, higher transmission speeds, fewer transmission errors, greater flexibility and shorter dial-up and connection times.

History

In the nineteen-fifties, there were basically two networks for telecommunication: the public switched telephone network (PSTN) and a digital telex network for written (typed) messages. Since its introduction, the analogue telephone network has seen few elementary changes, while the telex network is based on a primitive digital structure using a speed of 50 bits/s.

In the early seventies, the limited speeds and long switching times required to set up telephone or telex calls prompted network and telecom operators to investigate the feasibility of specialized digital network services. By and by, the telex network was phased out as it faced increasing competition from services using *packet switching*. In 1976, the X25 protocol for packet switching was accepted, allowing standard data rates of 4,800 and 9,600 bits/s.

Telephone goes digital, too

Alongside the above mentioned developments, the regular telephone networks underwent a change to digital technology. Using digital techniques, vast improvements were achieved in the speech quality on long-distance calls. The audio information (speech signals) was initially sampled at 8 kHz, as well as 8-bit encoded. The result is a datastream with a speed of 64 kbit/s. Since the early seventies, telephone network operators have gradually

pushed back the older analogue systems, replacing them with a digital infrastructure. The digitally enhanced trunk links have a capacity of 30 digital channels (23 in the USA) which are conveyed in interleaved fashion.

ISDN: THE BASIC TECHNOLOGY

In a nutshell, ISDN is the digital counterpart of the conventional analogue telephone line. The term Integrated Services means that a number of services are coupled to this infrastructure. The ISDN standard was laid down by the CCITT in 1984, and extended in 1988 by the European Telecommunication Standards Institute (ETSI).

An ordinary telephone connection has a bandwidth of about 3,100 Hz (300-3,400 Hz). The equivalent amount of information may be conveyed over a digital channel with a bandwidth of 64 kbit/s. In telecom lingo, this is called the B (bearer) channel. With ISDN, a 16-kbit/s D (diagnostic) channel is added to the B channel. With an ordinary telephone call, the B channel is used to exchange digitised speech, while it conveys data when two computers are connected to it. The extra D channel is a *common signalling channel* which is used to convey, for example, control information, electronic payment and personal identification, and signals generated by alarm systems. The extra services are supplied via this additional channel, and so do not affect the main channel.

In the UK, ISDN is supplied in two flavours by British Telecom: one using a system called Basic Rate Access (BRA, also called ISDN-2), and another called Primary Rate Access (PRA, also called ISDN-30). The essential difference between these two versions is the number of B channels put to the customer's disposal.

BASIC Rate Access ISDN

Basic Rate Access ISDN is the direct replacement for the analogue telephone line, and thus the obvious choice for private customers and SOHO (small office/home office) users. The actual connection is made via the traditional (already available) copper wires.

By exploiting the benefits of digital technology, a Basic Rate ISDN connection considerably expands the possibilities of an ordinary analogue connection. Each Basic Rate ISDN connection gives you two B channels with a digital bandwidth of 64 kbit each, and one D channel with a bandwidth of 16 kbit/s.

By trading in one analogue phone line against this basic ISDN connection, the subscriber gets two telephone lines which may be used independently. This allows you to surf the Internet or send long faxes while the other line is used to place or receive an ordinary phone call. With most ISDN equipment, these two lines may be connected to put a call through. Furthermore, it is possible to bundle the two B channels, which creates a single digital channel with a bandwidth of 128 kbit/s. An ISDN-2 connection allows up to eight extensions to be connected, of which two may be used simultaneously.

Primary Rate Access ISDN

The Primary Rate Access ISDN connection (ISDN-30) offers 30 independent B channels and one D channel with a capacity of 64 kbit/s (30B+D). A connection of this type is intended for professional users, for example, large companies, which may employ (and pay for!) ISDN-30 to enable their telephone exchange systems and local networks to communicate with the outside world.

Because of the large difference in capacity between Basic Rate and Primary Rate ISDN (2B+D versus 30B+D), some network operators also offer slimmed-down versions of PRA using, for example, six B channels (6B+D).

ISDN AT HOME

At the end user (customer) location, the two-wire ISDN connection has to be terminated with a so-called Linebox. This interface converts ISDN line signals to a 4-wire bus (called *S-bus* by BT and the CCITT), and employs a normal telephone cable.

There are two connection arrangements available for the ISDN equipment: point-to-point or point-to-multipoint. In point-to-point mode, one ISDN device is connected, and the cable may have a length of up to 1 km. In point-to-multipoint mode, up to eight ISDN devices may be connected in parallel, in which case the distance covered by the cable is reduced to about 200 m. The end of the S-bus is terminated by resistors, while the equipment is connected with the aid of an 8-pin version of the standard modular telephone plug (RJ-45).

Apart from two transparent B channels of 64 kbit/s each and the 16-kbit/s D channel, the S-bus also conveys bytes which arrange miscellaneous functions including synchronisation.

1

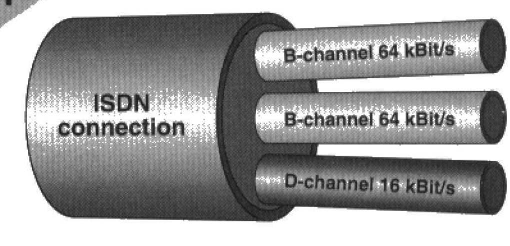


Figure 1. An ISDN-2 connection comprises two B channels with a capacity of 64 kbit/s each, to which is added one D channel with a capacity of 16 kbit/s.

2

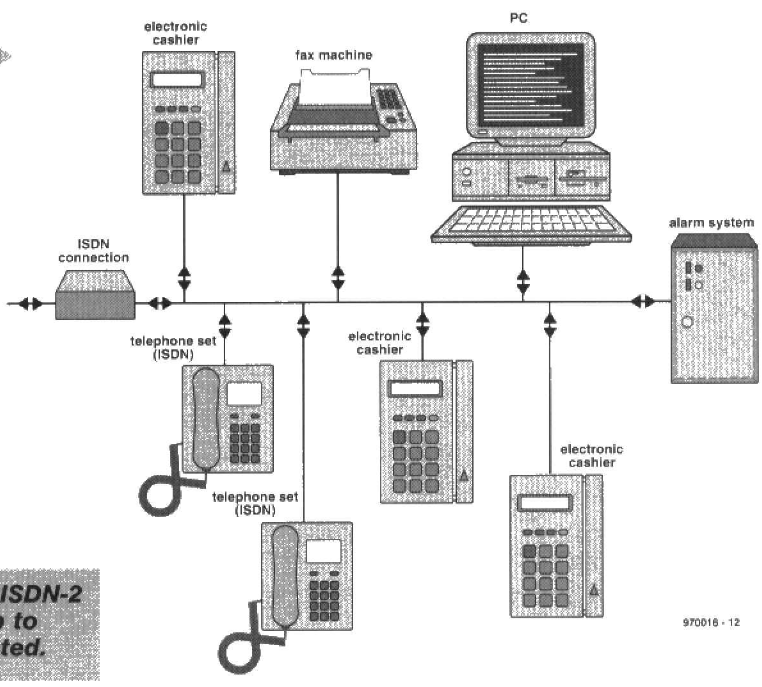


Figure 2. A standard ISDN-2 connection allows up to 8 users to be connected.

3

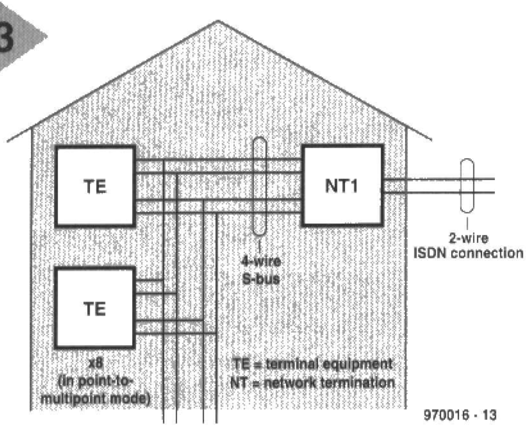


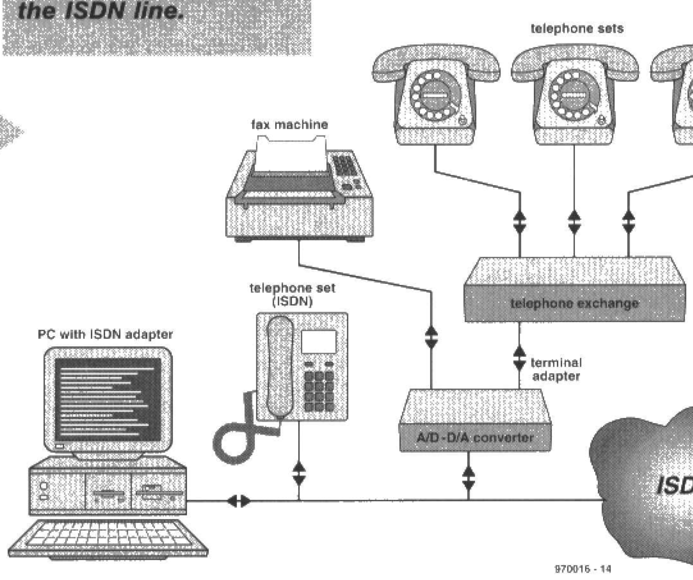
Figure 3. Depending on the number of extensions in the home (or small office) either a point-to-point or a point-to-multipoint link is set up to make the connections.

The control of the datastream involves an overhead bandwidth of 48 kbit/s, resulting in a total traffic of 192 kbit/s which may be conveyed via the S-bus.

In a system with several devices in parallel, each device (extension) is given access to the D channel using a special procedure. The B channel, however, is reserved for the device which was involved in establishing the connection. All other devices are excluded from this channel while the call lasts.

Figure 4. ISDN subscribers may continue to use their existing analogue telephone equipment. An A/D-D/A converter is inserted between the ISDN line and the 'old' equipment, while the newer ISDN equipment is directly connected to the ISDN line.

4



Euro ISDN

As is often the case when new services and/or options are introduced, an undesirable number of (partly) incompatible versions arises within a short period if there is no tight regulation right from the start. ISDN, too, was a sad example of this happening in practice. In many cases, national telecom operators set their own standards for local markets. Not a problem for most users, fortunately, because everyone within a one country will use the same system. A major stumbling block, however, for the development of a global or European market. Taking hardware across national borders is only possible if international standards are defined and accepted. In 1993, most European telecom operators signed a Memorandum of Understanding in which they agreed to offer services complying with a European standard: Euro ISDN. The following services and/or facilities have been defined for this standard:

- Basic Rate Access (BRA) and Primary Rate Access (PRA);
- a voice service which connects to the analogue standard;
- a data speed of 64 kbit/s per channel.

Furthermore, the following five *supplementary services* have been defined:

- Calling Line Identity Presentation (CLIP);
- Calling Line Identity Restriction (CLIR);
- Direct Dialling In (DDI)
- Multiple Subscriber Numbering (MSN);
- Terminal Portability (TP).

Supplementary services

As few of you will be familiar with the exact meaning of the above mentioned extra services, short descriptions are given below.

As implied by its name, *Calling Line Identification Presentation* (CLIP, actually a standard service with ISDN) ensures that the called customer can request the identity of the calling party. This option works within ISDN networks only, and may be disabled by the calling party for reasons of privacy.

Using the *Connected Line Identification Presentation* feature, the caller gets an identification of the called number as soon as the connection is established. If the number is not available, or set as not released by the called extension, the calling subscriber is notified accordingly. Two special functions, Calling Line Identity Restriction and Connected Line Identity Restriction, allow the displaying of phone numbers to be disabled for identity protection (per call or permanently).

Multiple Subscriber Numbering (MSN) enables up to eight directory numbers to be allocated to one ISDN-2 line.

Thanks to *Terminal Portability* (terminal disconnect/connect), an ISDN user may carry his/her ISDN terminal set to another socket on the same ISDN-2 line without losing the call.

In addition to these standard functions, lots of other services may be offered including billing information, number blocking, call announcement during a call, and connect-through functions. The availability of these *supplementary services* depends on what is offered by the telecom providers, and the demands of their customers. In most cases, supplementary services are offered at extra cost.

As already mentioned, each ISDN link has a D channel besides the B channels. The D channel is employed for the so-called carrier and teleservices. The carrier services play an important part in the linking of ISDN and the traditional telephone network, PSTN. In the ISDN infrastructure, the function of the teleservices is to ensure that the right extension/device of a customer is reached (for example, telephone set, fax or computer).

Bearer services

The bearer services indicate the type of information conveyed via an ISDN channel. The following bearer services have been defined for use within Euro ISDN:

- 64 kbit/s unrestricted;
- 64 kbit/s structured for speech;
- 64 kbit/s structured for 3.1-kHz audio.

Every ISDN link makes use of one of

5

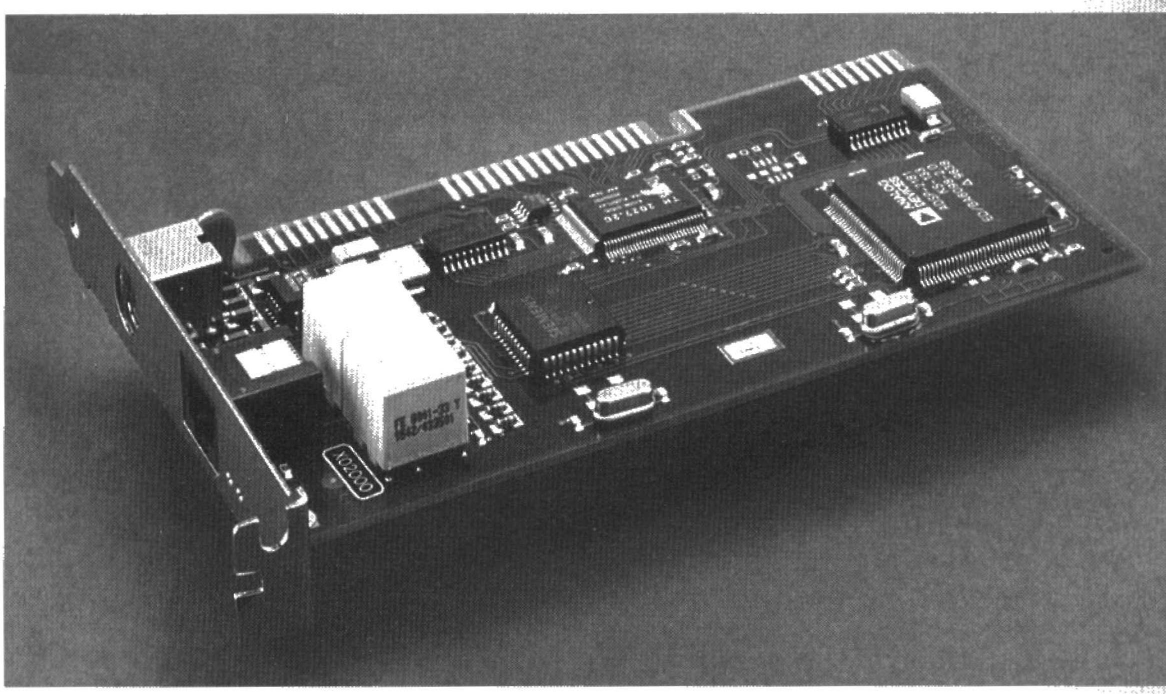


Figure 5. Using a special insertion card like the Eicon Diva Pro 2.0 pictured here, any PC may be linked to the ISDN network. This brings fast data connections within reach of any PC user.

these three services. Each time a connection is being set up, the right service is automatically selected. Although the data speed is 64 kbit/s in all three modes, it is still essential for the characteristics of the relevant information to be accurately known, mainly because the network operator makes different selections depending on the mode. An ordinary voice call, for example, has different requirements from a computer connection. With voice services, especially transatlantic ones, the usual selection is data compression. With data links, data corruption or loss can not be tolerated. An identification of the connection type thus makes it easier to make the best use of the available infrastructure in an efficient way. The overview below shows the options available for 'treating' (or processing) the datastream.

- In *64 kbit/s unrestricted* mode, a fully transparent link is employed, and data processing is not allowed.
- In *64 kbit/s structured for speech* mode, analogue-to-digital junctions may employ conversion to G.711/G.713. Underway, compression up to 32 kbit/s is allowed.
- The *64 kbit structured for audio* mode treats the datastream in the same way as speech signals, but then without recourse to echo cancellation circuits. This type of link is intended for analogue modems communicating via ISDN.

In addition to these standards, a number of other modes have been developed:

- 2 × 64 kbit/s unrestricted;
- 384 kbit/s unrestricted;
- 1,920 kbit/s unrestricted;
- Packet mode via the B channel;
- Packet mode via the D channel.

Teleservices

The teleservices indicate the purpose for which a link will be used, thereby allowing a feature called *end-to-end signalling*. The system enables, for instance, a Group-4 fax machine to be reached directly on an ISDN number which also has a telephone set and a PC with an ISDN connection. These features are automatically added to the datastream by the equipment or the application. Within the Euro ISDN system, a communication provider may decide to implement the following teleservices:

- Voice 3.1 kHz
- Teletext
- Group-4 fax
- Mixed mode
- Videotext

In this way, the use of teleservices provides a high degree of flexibility to any single ISDN connection. In the near future, further extension of the teleservices is feasible. Examples of added services include voice 7 kHz, message handling, video telephony, desktop/video conferencing, picture mail, film retrieval and audio retrieval. Some of these services are still under construction, while others are partly finished. Whether or not they will be used in practice is decided by the telecom providers.

(970016)

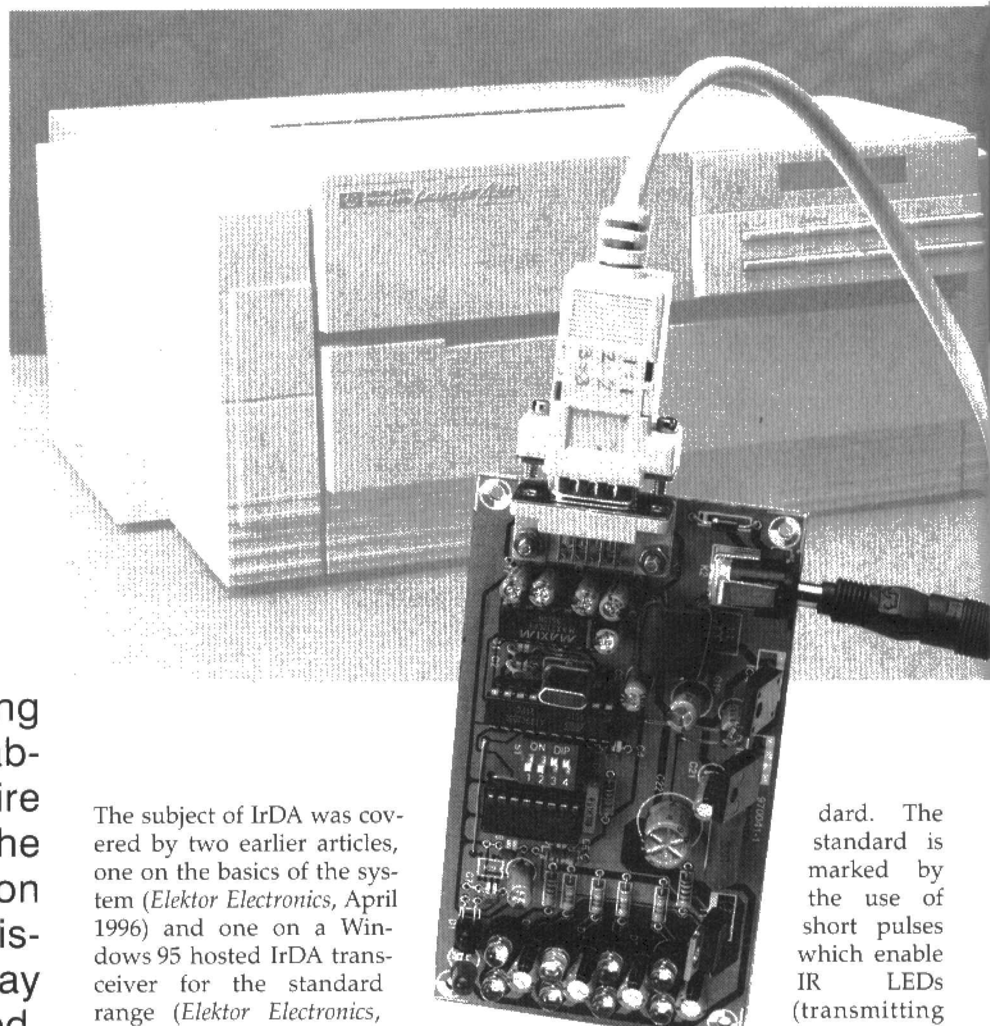
Analogue modems just as fast as ISDN?

As we write this, modem manufacturers are consolidating a new standard to achieve a data speed of about 56 kbit/s using 'ordinary', analogue telephone lines. This would make data communication across an analogue line almost as fast as across an ISDN line. But do these connections offer exactly the same features? To enable the highest possible data speed to be achieved on an analogue line, a number of conditions have be satisfied. For instance, the user has to be connected to an all-digital (System-X) local telephone exchange. Such an exchange always leaves a small part of the clock signal on the line. The new modems use this 'residue' to synchronise. A point which is often forgotten in discussions about 56-kbit modem technology is that the fast connection is only one-way: from an ISDN connection (i.e., the digital exchange) to an analogue connection. Consequently, two users, each having an analogue connection, will never be able to realise a 56 kbit/s link between them. However, Internet providers in particular will welcome the new technology, as it enables them to offer a fast connection to customers having analogue modems.

long-distance IrDA link

infrared data link covers up to 20 m

The infrared data link discussed in this article is based on the IrDA (Infrared Data Association) standard, and is suitable for any modern computer in combination with any peripheral device having an RS232 serial interface. The long-distance IrDA system goes even further, however. A full-duplex mode operating at up to 19.2 kbit/s coupled with RTS/CTS handshaking enables links to be established which used require cables. In contrast with the standard IrDA specification (range up to 3 m), distances of up to 20 m may be covered.



MAIN SPECIFICATIONS

- *replaces serial cable connection by infrared*
- *suitable for all computers and peripherals*
- *range of over 20 m*
- *beam pointing not required with shorter links*
- *RS232 compatible*
- *IrDA 1.0 compliant (2.4-115.2 kbit/s)*
- *no special driver(s) required*
- *choice between half-duplex and full-duplex*

Design by P. Höpping and W. Hackländer

The subject of IrDA was covered by two earlier articles, one on the basics of the system (*Elektor Electronics*, April 1996) and one on a Windows 95 hosted IrDA transceiver for the standard range (*Elektor Electronics*, November 1996). The latter design (which was a first for home construction) allows a half-duplex link to be set up which runs at up to 115,200 bits/s. The typical distance covered by this system is about 1 m, or 3 m maximum, while the transceivers have to be accurately pointed at one another because of the optical aperture angle of 30° (±15°).

Like the add-on transceiver design published in the November 1996 issue, the IrDA interface typically found in today's laptop and notebook computers complies with the IrDA standard. The standard is marked by the use of short pulses which enable IR LEDs (transmitting devices) to be operated at high (pulsed) currents. The pulse length of the serial signal on the RS232 interface, however, depends on the programmed bit rate, and is, therefore, variable. The IrDA interface converts a serial bit with logic value '0' into a pulse with a minimum and maximum length of 1.6 μs (default) or 3/16th of the RS232 bit duration, respectively. To be able to recover the original bit length of the RS232 signal, the bit rate has to be known, in other words, the IrDA interface has to be programmed to operate at the right bit rate.

Apart from the range that can be

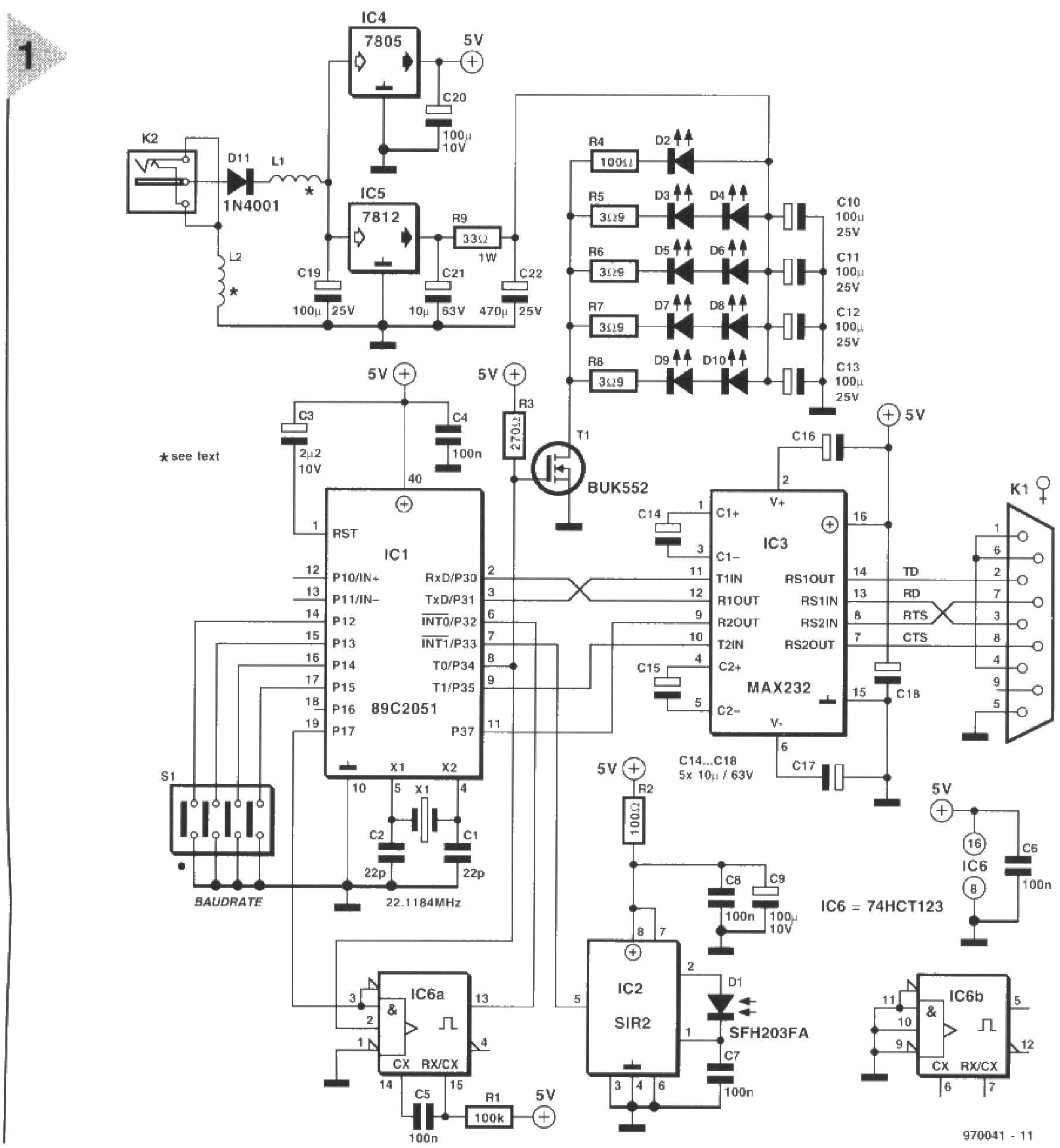
Figure 1. Circuit diagram of the long-distance IrDA interface. A microcontroller handles all bit rate settings, transmission control (full/half duplex), as well as everything to do with the conversion of the RS232 signals into IrDA-compliant 1.6-µs pulses (and the other way around).

covered reliably, the IrDA standard is also marked by restrictions as regards data security. Because the receiver converts each received IR pulse into a serial bit, it is unable to detect the difference between the odd noise pulse and a start bit of a serial byte representing the value 0FFh. Despite the use of an AGC (automatic gain control) in the receiver, noise-induced bytes may occur if the optics are misaligned. In practice, however, few problems will occur as long as the receiver is not pointed directly at a noise source (for example, an electric bulb). A possibly annoying factor, however, is the half-duplex nature of the link, which requires a certain recovery time to be built into the transceiver to prevent the receiver being overloaded by the local transmitter.

Long-distance IrDA

Apart from the standard IrDA mode, the long-distance IrDA interface offers an extended mode which achieves bit rates of up to 19.2 bits/s using RTS/CTS handshaking. As opposed to the extended (full-duplex) mode, the (half-duplex) standard mode is IrDA compatible. There is only one deviation from the IrDA standard in that the transmit power has been optimized for relatively large distances (up to 20 m).

1



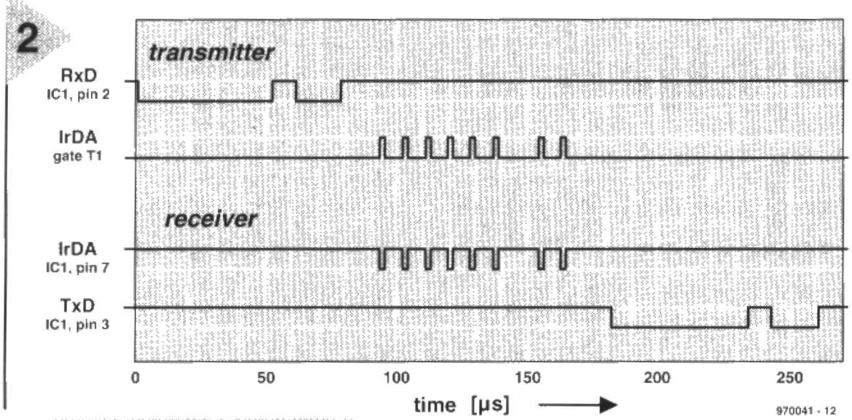


Figure 2. RS232 data and the IrDA signal in transmit and receive mode. The shift between the two signals is caused by the latching operation (byte-wise processing) of the UART in the microcontroller.

Table 1. data rate setting				
bit rate	SW4	SW3	SW2	SW1
(bits/s)	(1 = closed, 0 = open)			
1200	0	0	0	0
2400	0	0	0	1
4800	0	0	1	0
9600	0	0	1	1
19200	0	1	0	0
38400	0	1	0	1
57600	0	1	1	0
115200	0	1	1	1
1200 *)	1	0	0	0
2400 *)	1	0	0	1
4800 *)	1	0	1	0
9600 *)	1	0	1	1
19200 *)	1	1	0	0
*) full duplex				

The obvious advantage of the higher power is that it is no longer necessary to accurately point the receiver and transmitter at each other if shorter distances are covered, say, in an average sized office.

The use of a special IrDA driver with the standard-range transceiver discussed in last year's November issue causes two restrictions: the interface is only suitable for Windows 95, and it can not be used with a peripheral device such as a printer (unless, of course, in the rare case of the printer having a built-in IrDA interface). Because of this, the present long-distance IrDA interface does not employ software-controlled bit rate settings. In fact, the bit rate is set by means of DIP switches as shown in **Table 1**.

WITH CONTROLLER

A microcontroller is employed for generating the bit rates, the conversion of RS232 signals into IrDA pulses, and the recovering of RS232 signals from IrDA pulses. An Atmel AT89C2051 single-chip microcontroller is used in the circuit (**Figure 1**). This controller is compatible with the industry standard 80C51 as regards internal architecture and instruction set, offering 2 kBytes of ROM, 128 bytes of RAM, a UART and two timers. A particularly useful feature of the 89C2051 is that the ROM range is actually implemented as an electrically programmable and erasable Flash EPROM, so that the controller may be erased and reprogrammed without having to expose it to UV light. Another advantage is that the Atmel controllers are so cheap that they may also replace OTPs (one-time programmable PROM memories). Finally, the Atmel 89C controllers are pretty fast, too – here, the CPU operates at a clock speed of 22.118 MHz.

In transmit mode, the controller supplies a 1.6-μs pulse for each 0-bit received from the RS232 interface via the MAX232 level converter. Alternatively, several 1.6-μs pulses may be supplied because the 'dead' (recovery) time is filled with pulses. In receive mode, the controller has to detect the occurrence of an infrared pulse within a certain period. If such a pulse arrives, the value of the bit is '0', else, it is '1'. The basic IrDA system timing is illustrated in **Figure 2**.

The 1.6-μs pulses supplied by pin 8 in transmit mode drive the gate of T1, an n-channel 5-volt logic-level compatible MOSFET. The FET switches the pulse current through the special IR transmitter LEDs, with double limiting of the maximum current. On the one hand, the 3.9-Ω resistors (R1-R8) limit the peak current through the series-connected transmit diodes to about 1.5 A. This amount of current is only allowed, however, if the pulse/pause ratio (duty factor) is smaller than 0.01. With higher bit rates, the duty factor rises with the number of pulses per second, enabling resistor R9 to provide additional current limiting. As a matter of course, the high peak currents through the LEDs call for suitably dimensioned copper tracks on the circuit board.

For short pulses, reservoir capacitors C10-C13 and C22 act as voltage sources with a low internal resistance. The eight high-power IR-LEDs type TSHA6203 (from Temic) are specially designed for long-range digital

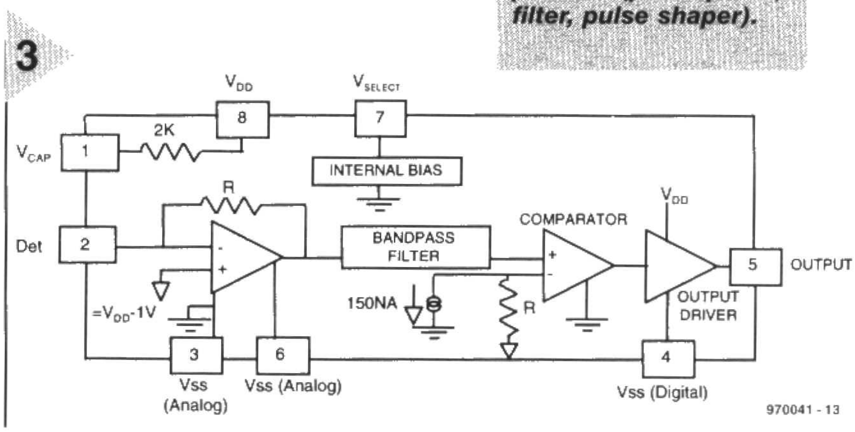


Figure 3. Block diagram of the IrDA receiver IC type SIR2 from Novalog Inc. This complex chip contains all the necessary components (preamplifier, filter, pulse shaper).

4

D7	D6	D5	D4	D3	D2	D1	D0
1	0	1	0	1	0	CTS	data

Figure 4. Structure of the control byte, which is continuously bounced back and forth between two long-distance IrDA boards.

COMPONENTS LIST

Resistors:
R1 = 100kΩ
R2,R4 = 100Ω
R3 = 270Ω
R5-R8 = 3Ω9
R9 = 33Ω 1W

Capacitors:
C1,C2 = 22pF
C3 = 2μF2 10V radial
C4,C6,C7,C8 = 100nF
C5 = 100nF MKT
C9,C20 = 100μF 10V radial
C10-C13,C19 = 100μF 25V radial
C14-C18,C21 = 10μF 63V radial
C22 = 470μF 25V radial

Inductors:
L1,L2 = 2-hole ferrite bead, 0.4mm CuL wire, see text

Semiconductors:
D1 = BPV23NFL (Temic) or SFH203FA (Siemens)
D2 = LED, red, high efficiency
D3-D10 = TSHA6203 or TSHA5203 (Temic) (IR diode, 12°, 875nm)
D11 = 1N4001
T1 = BUK552 (Philips Semiconductors)
IC1 = AT89C2051-24PC (programmed, order code 976504-1)
IC3 = MAX232ECPE
IC4 = 7805
IC5 = 7812
IC6 = 74HCT123
IC2 = SIR2 (Novalog)*

Miscellaneous:
X1 = 22.1184MHz quartz crystal
S1 = 4-way DIP switch
K1 = 9-way sub-D socket, angled pins, PCB mount
K2 = mains adapter socket
Enclosure: approx. size 120x70x30mm
PCB and programmed 89C2051: order code 970041-C.
* Available from C-I Electronics, fax (+31) 10 4861592

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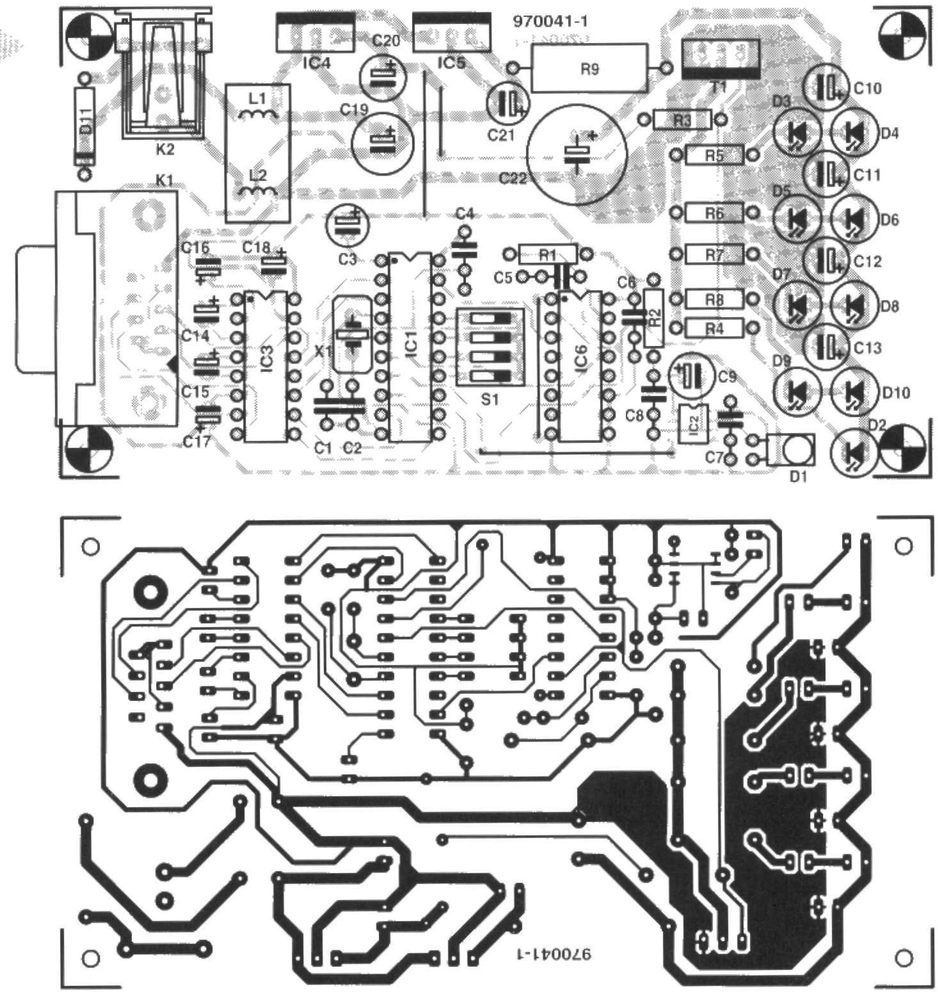


Figure 5. Track layout and component mounting plan of the PCB designed for the interface. Board available ready-made through the Publishers' Readers Services.

infrared transmission systems, high pulse loading capacity and short turn-on times. The rise and fall times, for example, are just 300 ns at a pulsed current of 1.5 A. Another equally important aspect is, of course, that the radiation wavelength of 875 nm matches the spectral sensitivity of the p-i-n photodiode, D1, employed in the receiver circuit.

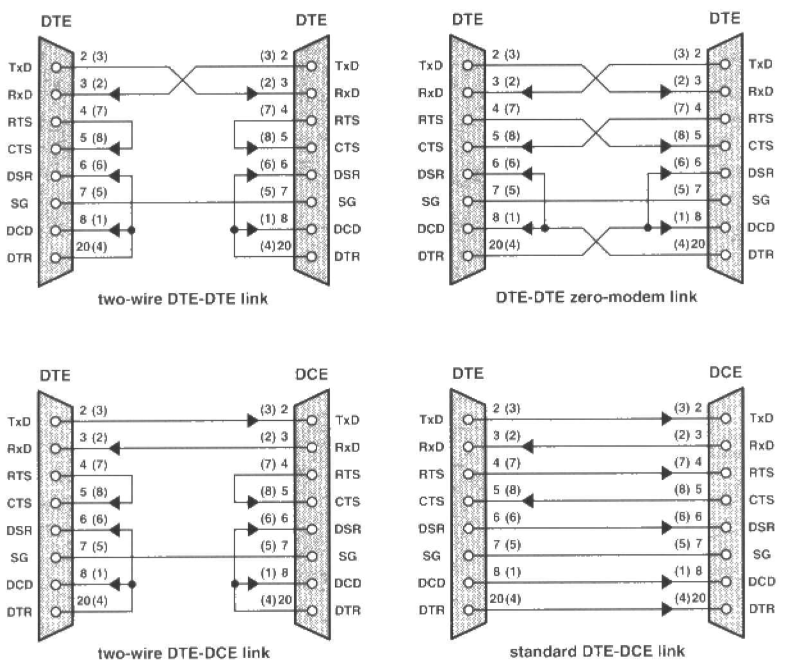
Apart from the IR transmitter diodes, the MOSFET also drives a regular red LED, D2. This LED is useful as a visual transmit indicator. In full-duplex mode, the LED lights brightly, indicating a properly operating infrared link. If there is no communication, the LED lights only dimly.

The IR receiver section consists of one, special, IC in combination with the IR receiver diode. The special IC is a type SIR2 IrDA receiver from Novalog. This chip is IrDA-1.0 compliant, i.e., it is capable of handling data rates between 2.4 and 115.2 bits/s. As indicated by the block diagram in **Figure 3**, this one-chip IR receiver contains a sensitive preamplifier stage, a comparator for pulse shaping, and an output driver. The IR photodiode is directly connected to the IC input, with a 100-nF capacitor, C7, decoupling the cathode to ground. The supply voltage for the receiver IC is decoupled with the aid of R2, C8 and C9. The received IrDA pulses are available with TTL compatible swing at the buffered output. The microcontroller, IC1, handles their processing. The output of the receiver chip, pin 5, is connected to the P3.3 (INT1 interrupt) line of the microcontroller.

In addition to a microcontroller, an IR receiver and an RS232 converter, the long-distance IrDA circuit also contains a type 74HCT123 monostable multivibrator, IC6A. In full-duplex mode, this IC generates an interrupt when the infrared link fails.

The circuit is powered by an ordinary mains adaptor with a rating of about 12 V/0.3 A. The adaptor is connected to the circuit via socket K2. The reverse polarity protection, D11, is followed by an L-C filter, L1-C19, which

RS232 troubleshooting



DTE = data terminal equipment DCE = data communication equipment

In principle, an RS232 link consists of three wire pairs. As far as differences exist between pin numbers on 9-way sub-D and 25-way sub-D connectors, the numbers in brackets apply to the older 25-way version (also in the drawings).

- *data: RxD and TxD at pin 2 or 3 (3 or 2)*
- *handshake 1: RTS and CTS at pin 4 or 5 (7 or 8)*
- *handshake 2: DSR, DCD and DTR at pin 6, 8 or 20 (6, 1 or 4)*

The RS232 interface appears in so many versions that a new link may not always function spot-on. If DOS reports a write error to a COM port, the most likely cause is a fault in the handshaking system. This may be resolved as follows.

Of each of the wire pairs mentioned above, one wire is an input, and the other, an output. It seems logical to always have an input (for example, at the computer side) connected to an output (for example, at the printer side). If the relevant wires are crossed, then outputs and inputs are interconnected, which makes no sense. If you are hesitant about soldering inside the relevant plug, or even unable to do so (for example, because of a moulded plug case), then an insertion-type adapter may be employed to correct the situation with the crossed wires. An output is easily identified using a multimeter, because it normally supplies a negative or a positive voltage of 10 V or thereabouts (usually, the range is 8 to 11 volts). Inputs, on the other hand, are usually at 0 V, or a low voltage (smaller than 2 V).

So, in case of problems, take a deep breath and cheerfully start measuring potentials on the serial ports of the PC and the peripheral device. If, for example, a voltage of –10 V is measured on pin 2 at both sides of the link, an insertion adapter has to be made (in the simplest case, two sub-D connectors fitted back-to-back with short wires between the pins). Pin 2 is then crossed over to pin 3, and pin 3, to pin 2. If, on the other hand, pin 2 is at – 10 V at one side, and at 0.9 V at the other side, pin 2 may be connected to pin 2, and pin 3, to pin 3.

The same procedure applies to the other wire pairs, and the RS232 link will almost certainly function if everything is properly measured and connected. Do not forget to connect pin 7 (5) to pin 7 (5) to establish the indispensable ground link. The drawing shows all four variants which exist for RS232 serial links. The long-range IrDA board has a 9-way socket with a standard DTE-DCE pinout.

suppresses noise. All ICs receive their 5-V supply voltage from voltage regulator IC4. The LEDs, on the other hand, are powered by IC5, operating at 12 V.

Full duplex

In full-duplex mode, the transmitter and receiver 'bounce' a control byte back and forth all the time. In this 'dialogue', the actual information is inserted between the control bytes. **Figure 4** shows the contents of the control byte, which may be any bit pattern, as long as it is dissimilar from the occasionally occurring noise pulses. Only bits 0 and 1 have an additional function:

When D0 (data) is at '1', the transmitter informs the receiver that the control byte will be followed by a data byte. If the data bit is at '0', no data follow, and the circuit is switched to receiving.

Bit D1 (CTS) is set to the value which exists at the CTS input of the RS232 interface. The receiver then supplies this value at the RTS output.

Because only a part of the transmission time is actually used for data bytes, the transmitter and receiver internally operate at a bit rate which is 6 to 8 times higher than the speed of the data conveyed over the IR link. For example, if the speed of the infrared link is set to 19.2 kbit/s, an internal bit rate of 115.2 kbit/s is used. In full-duplex mode, this creates the following constantly repeating sequence:

1. Transmit control byte. Set bit D0 if the RS232 interface has serial data available for transmission;
2. If data are ready and available, transmit them, else continue at step 3;
3. Wait for control byte;
4. Process control byte. Copy value of bit D1 to RTS. If bit D0 is at '0', return to step 1, else continue with step 5;
5. Receive data byte and output it via the RS232 interface. Return to step 1.

As you can easily see, the two IR transceivers wait at step 3 when the link is interrupted. In that case, the monostable causes a restart after some time. Because of the maximum data speed of 115.2 kbit/s, it was necessary to optimize the entire program by having the CPU count clock cycles. The eight bits that form a byte are therefore processed linearly rather than in a loop structure.

Because the full-duplex mode is asynchronous in a number of respects, the setting of the serial port should include the parameter '2 stop bits'. Particularly at lower bit rates, when the computer comes very close to the theoretically possible data transmission speed, small delays could add up and cause data loss under certain conditions.

Construction and test

There is a choice between two component types which may be used in the transmitter, and the same goes for the receiver: TSHA6203 or TSHA5203 for the IR LEDs (both from Temic), and SFH203F (Siemens, Farnell) or BPV23NFL (Temic) for the receiver diode. The SFH203F has the same case as the LEDs, which makes it easier to fit.

Start the population of the board (**Figure 5**) with the passive parts and the IC sockets. The ICs, including IC2, are not fitted yet. Check the value of R9 to make sure the LEDs work in the safe operating area. The IR LEDs <u>must</u> be fitted the right way around! The cathode terminal is at the flat side of the enclosure. Next, connect the 12-V mains adapter, and use a DMM to check the voltages at the regulator outputs (5 V on C20, 12 V on C21). If the 12-V supply is too low, temporarily tie the gate of T1 to ground. The LEDs then stop drawing current, and the supply voltage should be at 12 V.

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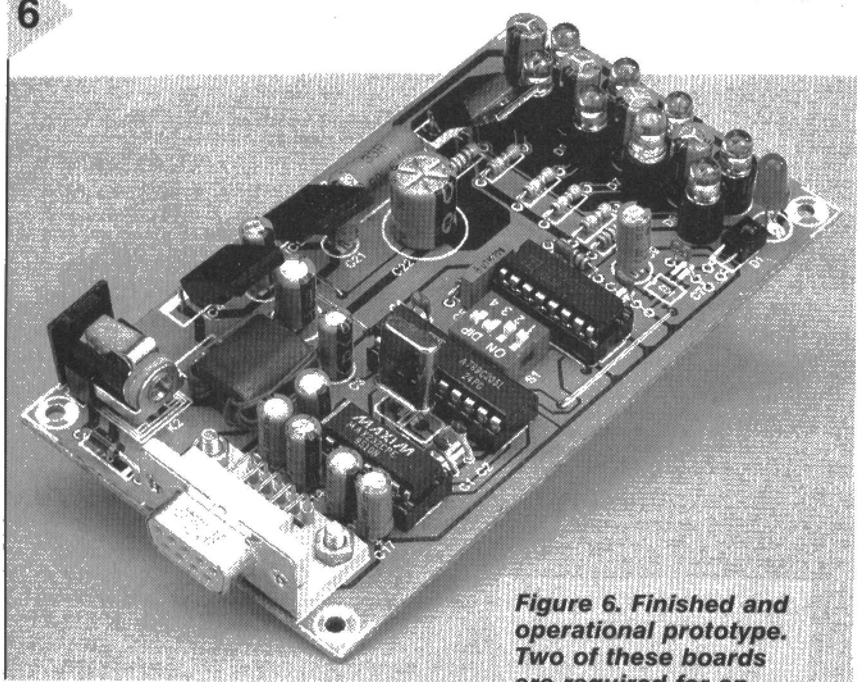


Figure 6. Finished and operational prototype. Two of these boards are required for an IrDA link between two devices having a serial interface.

Remove the ground connection. LED D2 should light brightly, and R9 should drop about 8 V. If everything is all right so far, the supply may be switched off, the ICs inserted in their sockets, and IC2 soldered in place. If the supply is connected again, D2 should light up briefly, and then very dimly. Using an oscilloscope, you may examine the processor's oscillator signal at pins 4 and 5, and the transmitter pulses at the IR diodes (or at the gate of T1). In half-duplex mode at 9,600 bits/s, the scope should indicate six 1.6-μs pulses, the first four spaced at about 9 μs, and the last two, at about 17 μs. This pulse train is repeated every 3.5 ms, which corresponds with the period of the monostable.

As soon as a second, fully operational, long-distance IrDA board comes in range, the two units will start to communicate, even if an RS232 link has not been set up yet with a computer or a peripheral. In this active state, the current consumption of a board is just over 100 mA. If no communication is established, then at least one of the two boards is not functioning properly. Try to establish the presence of received pulses at pin 7 of the microcontroller (connected to the output of the IR receiver, IC2). When the other board has no supply voltage, pin 7 will supply the six pulses sent by the local transmitter. Once the other board is powered up, additional pulses (those from the receiver) should appear on the scope. This test is repeated with the other unit as the board on test. In this way, you are able to find out if a board transmits and receives, as well as which board is doing so.

Inductors L1 and L2 consist of a few turns of enamelled copper wire with a diameter of about 0.4 mm (SWG28) through a small ferrite bead with two holes. These inductors act as RF chokes, and their actual inductance is uncritical.

Because capacitors C10 through C13 and C22 are fairly heavily loaded by pulse-shaped currents, it is recommended to employ special versions as found in switch-mode power supplies. These capacitors are marked by a low internal resistance, and better endurance under heavy loading conditions. Because suitable types like the 25V101MA31 from RSH are rare birds and by no means commonly available, 'normal' electrolytic capacitors may also be used, provided they are from reputable manufacturers, and known to be suitable for use in switch-mode power supplies.

APPLICATION

Connecting-up is easy: the cable from the RS232 interface on the computer or the peripheral device is connected to the RS232 socket on the long-distance IrDA board. So, one board may be connected to your PC's RS232 port, and the other board, to a printer. Obviously, no wires or cables are connected between the two IrDA boards, as their communication is by means of (invisible) light. With relatively short distances, say, within an office, an indirect link is possible, that is, walls and ceilings may be used to reflect the infrared beams. As a matter of course, the range of the system with non-aligned boards is more likely to be degraded by direct sunlight, incandescent bulb light and similar light sources, than in the case of a line of sight path.

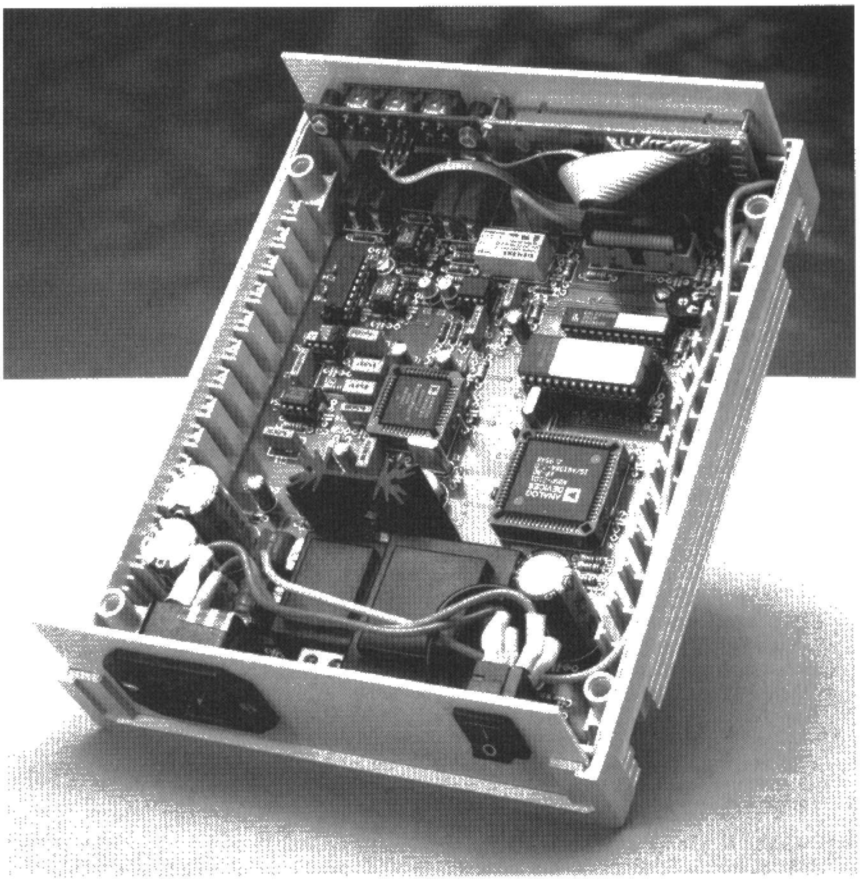
A line of sight path and accurate pointing of the optics are essential if you want to use the IrDA link to cover distances of up to 20 m. Also, precautions should then be taken to ensure that the IR beams are not interrupted, because that may cause transmission errors which are beyond correction.

An obvious condition for a serial link between two IR boards is that the equipment at both sides operates properly in combination with an RS232 cable connection. The crucial point in connecting the long-distance IrDA boards is the right connector layout and pinning. Unfortunately, differences abound in this respect, so that it may be necessary in some cases to swap a couple of wires before the RS232 connection is up and running (see also the 'RS232 troubleshooting' inset).

(970041)

advanced LCR meter

Part 2: Construction



The design considerations and the circuit layout of the LCR meter were described in last month's first part of this three-part article. This second part describes the construction of the instrument. Because of the required precision, ample screening is needed, but with some dexterity the construction will prove to be not too demanding. The careful work will be rewarded by an instrument with excellent properties.

Design by H. Bonekamp

Because of the use of integrated components, the number of building blocks constituting the *LCR* meter has been kept small, as may be seen in the introductory photograph showing the instrument with upper half removed.

Since small signals and well-defined parasitic impedances are used, good screening is required in several places. The resulting tin-plate screens form an important part of the construction. Note that any deviations from the described screening may adversely affect the performance of the instrument.

The printed-circuit board, the various screens and the front panel are all designed for use with the specified enclosure.

The instrument should be built on the double-sided, through-plated printed-circuit board shown in **Figure 5**. Start the construction by cutting the switch (S_1–S_3) section and a little extra from the main board. The extra piece of board removed makes space for the liquid-crystal display (LCD) that will be fitted to the inside front panel. When the section has been cut out, hold the main board in the enclosure to see that it fits. Note that the six ventilation slots are at the rear of the enclosure, where later the mains inlet and on/off switch will be located.

Of the various tapped bosses in the bottom half of the enclosure only five are to be retained: four to screw the board to and one coinciding with the space left by the extra piece of cut-out board. The superfluous bosses are easily removed with a sharp knife or a 10-mm drill. When this is done, try the board for a correct fit again.

Gouge out a little material from the bottom panel of the lower half of the enclosure underneath PC_4 (to make

Parts list

Resistors:
R_1, R_{18}, R_{22}-R_{28}, R_{30} = 10 kΩ
R_2-R_5 = 10 kΩ, 1%, high stability
R_6, R_{19} = 100 Ω
R_7 = 100 kΩ, 0.1%, high stability
R_8 = 100 Ω, 0.1%, high stability
R_9 = 4.7 kΩ
R_{10} = 10 Ω
R_{11}-R_{16} = 1 kΩ, 1%, high stability
R_{17} = 5.49 kΩ
R_{20} = 18 kΩ
R_{21} = 12 Ω
R_{29} = 22 kΩ
R_{31} = 1.5 Ω
P_1 = 10 kΩ preset, horizontal mounting

Capacitors:
C_1 = 56 pF
C_2 = 65 pF trimmer
C_3, C_5, C_{18} = 10 μF, 10 V, radial
C_4, C_{10}, C_{15}, C_{20}, C_{22}, C_{24}, C_{28}, C_{29}, C_{31}-C_{40}, C_{43}-C_{54} = 100 nF, high stability
C_6, C_7 = 1 μF*
C_8, C_9 = 1 nF*
C_{11} = 470 nF*
C_{12}, C_{13} = 200 nF*
C_{14} = 47 nF*
C_{16}, C_{17} = 22 pF, ceramic
C_{19} = 150 pF, ceramic
C_{21} = 2200 μF, 16 V, radial
C_{23}, C_{25} = 1000 μF, 35 V, radial
C_{26} = 300 nF*
C_{27}, C_{30}, C_{41}, C_{42} = 10 μF, 16 V, radial
* = MKT (metallized polyester)

Semiconductors:
D_1, D_6, D_7 = 1N4148
D_2, D_3 = BAV45
D_4, D_5, D_8 = BAT85
D_9-D_{12} = 1N4001
D_{13}-D_{16} = 1N4002
D_{17} = zener, 5.6 V, 1.3 W
D_{18}, D_{19} = zener, 16 V, 1.3 W
T_1 = BC337

Integrated circuits:
IC_1 = AD1847JP
IC_2 = AD847JN
IC_3, IC_4 = OP282GP
IC_5 = ADG433BN
IC_6 = AD620AN
IC_7 = PGA103P (Burr-Brown)
IC_8 = 27C512 (976507—see Readers services toward the end of this issue)
IC_9 = ADSP2101 KP80
IC_{10} = 22V10 (976506—see Readers services toward the end of this issue)
IC_{11} = ST93C46CB1 (SGS)
IC_{12} = 7805
IC_{13} = 7815
IC_{14} = 7915

Miscellaneous:
L_1 = inductor, 100 μH
Re_1 = relay, Siemens V23042-A2001-B101
S_1-S_3 = Push button switch D6-R-RD with protective cap D6Q-RD-CAP (ITT)
X_1 = crystal 24.576 MHz
X_2 = crystal, 10 MHz
Tr_1 = Mains transformer, secondary 9 V, 4.5 VA (e.g., Velleman 1090050M from Maplin)
Tr_2 = Mains transformer, secondary 2×15 V, 1.5 VA (e.g., Velleman 2150018M from Maplin)
PC_1, PC_2 = PCB mounting phono socket, red
PC_3, PC_4 = PCB mounting phono socket, black or white
K_1 = 6-pin mini DIN socket
K_2 = 20-way PCB mounting box header, straight
K_3 = 4-pin single-row IC socket
K_4 = 2-way PCB mounting terminal block, pitch 7.5 mm
Heat sink, 11 K W^{-1}, Fischer SK104/38.1 (Dau – phone 01243 553 031)
LCD, L1642B1J000, 16×2 characters (Seiko)
Enclosure, UM32009L with 2 off FPK 30018 (front and rear panel) and 1 off UM-ASK (feet) (Bopla from Phoenix Mecano, phone 01296 398 855)
F_1 = fuse, 50 mA, slow
S_4 = double-pole mains on/off switch
Mains inlet with integral fuse holder
20-way flatcable about 15 cm long
PCB+GAL+EPROM Order No. 970028-C or if board not required: GAL Order No. 976506 and EPROM Order No. 976507

5a

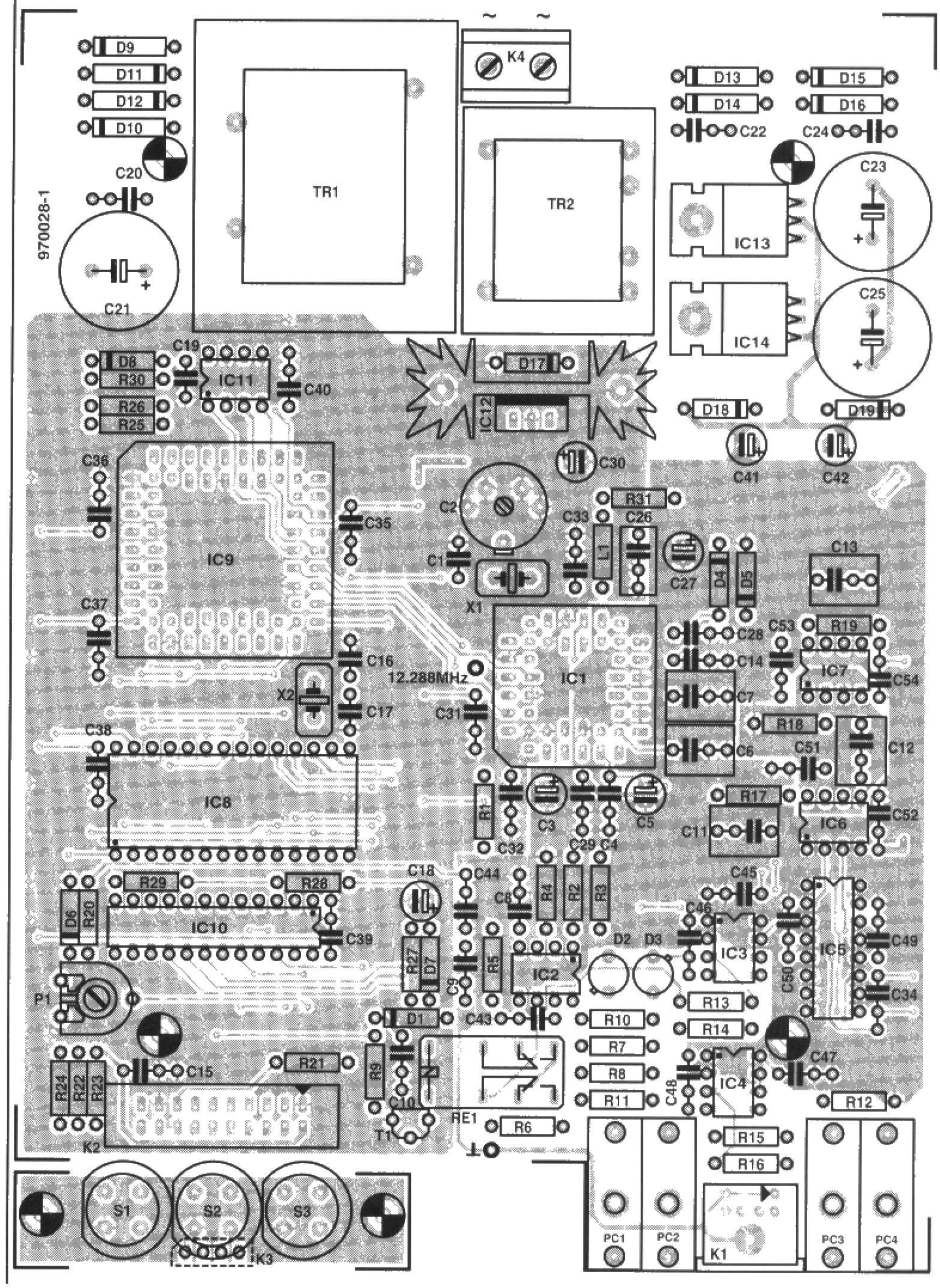
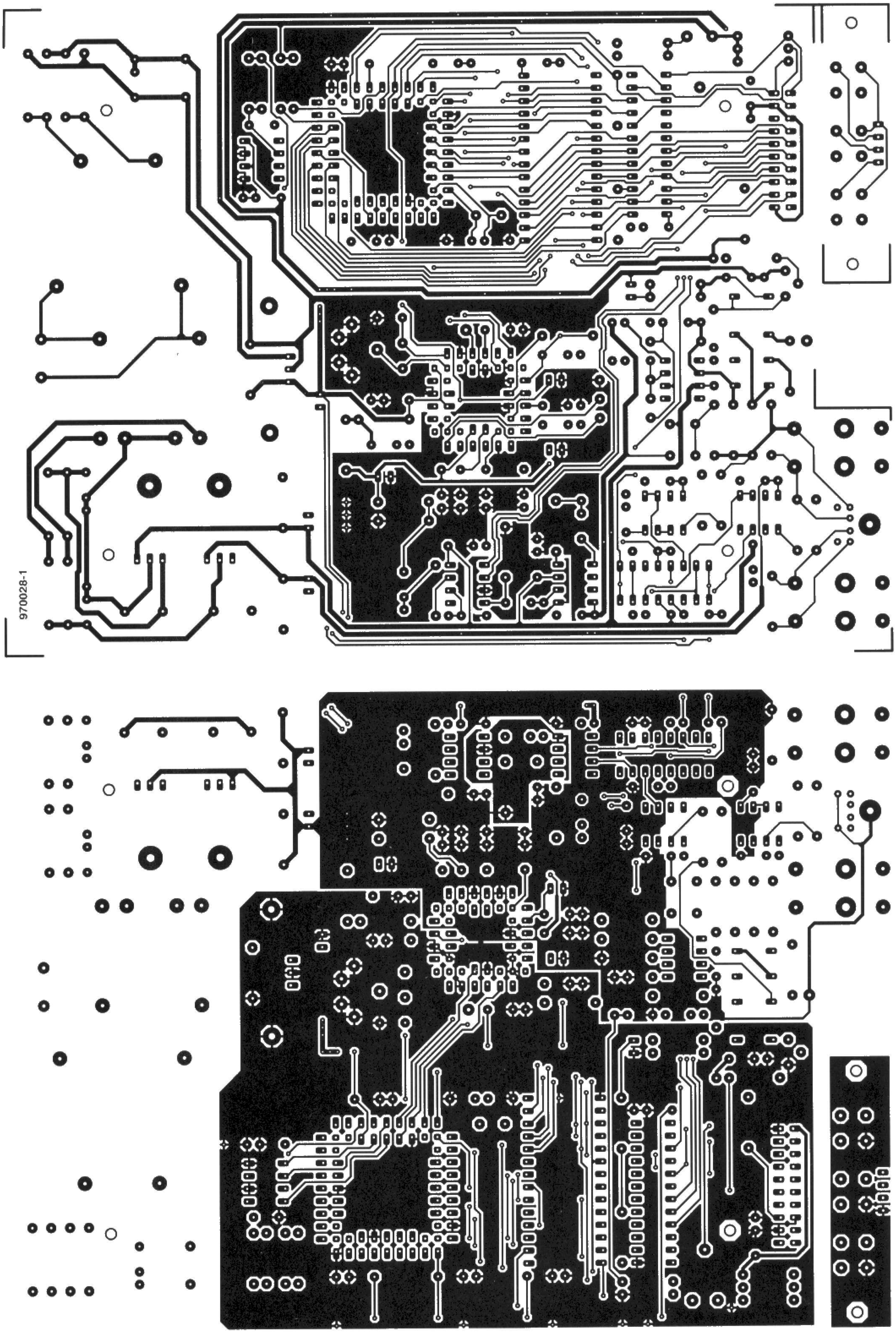


Figure 5a. Component layout of the printed-circuit board for the LCR meter.

5b



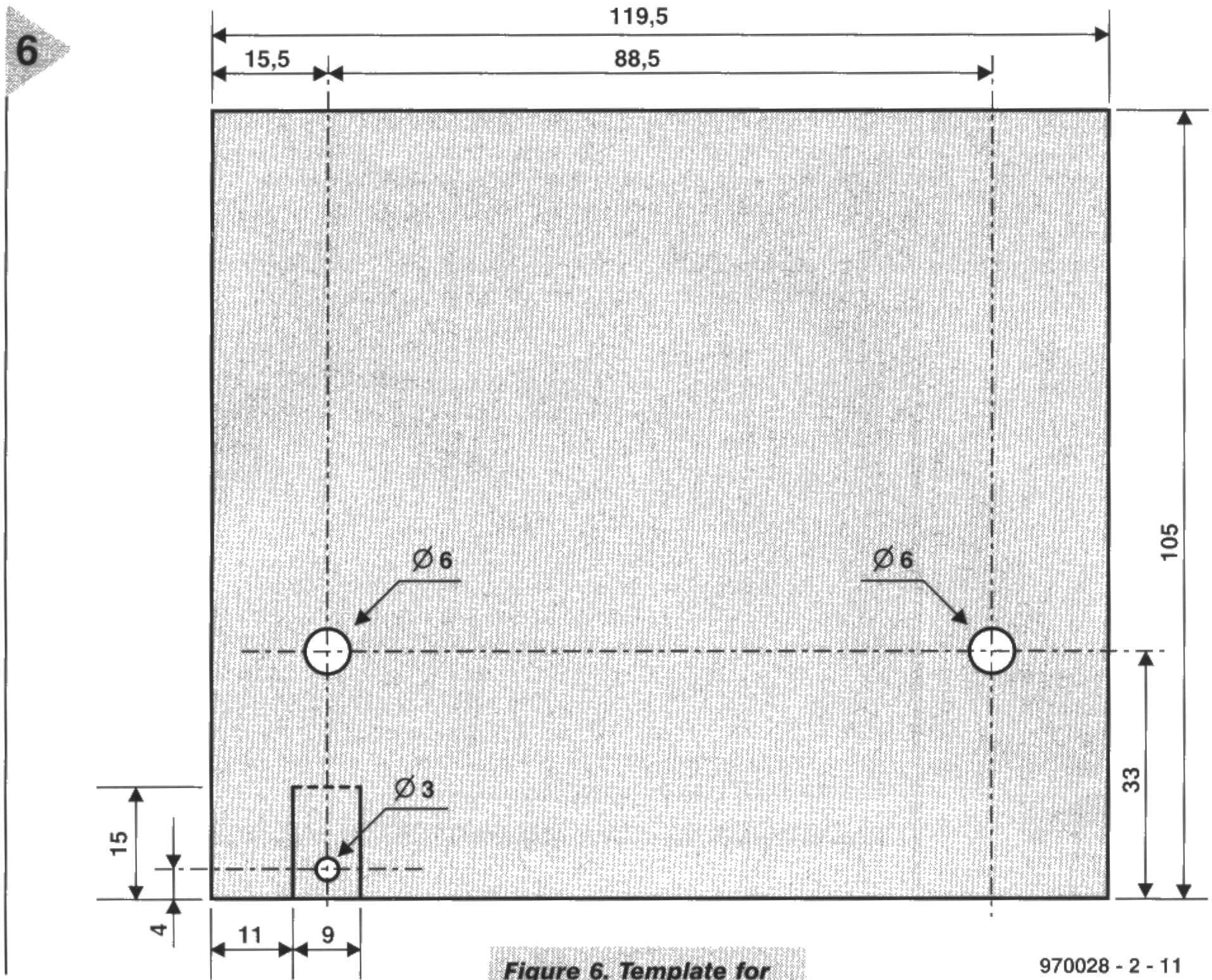


Figure 6. Template for making the tin-plate screen for the lower half of the enclosure. For safety reasons it is vital that the exact dimensions are observed.

space for the fixing screw of this component) and R_{12} and D_{19} (to make space for the solder pads).

A screen is needed in the lower half of the enclosure. This is made by cutting a strip of 0.5 mm thick tin-plate into the shape shown in **Figure 6**. Note that this must be the exact size specified to prevent safety problems (the mains voltage input to the transformers is present at the track side of the board). Make the cuts for the small lip (bottom left-hand of Figure 6) and drill the three specified holes in the tin plate. Bend the screen along the lines indicated and turn the cut-out lip slightly inwards. The screen should now fit neatly into the bottom half of the enclosure. Secure it in place with araldite or superglue and fasten the lip on to the fifth tapped boss with a self-tapping (preferably nylon) screw.

SOLDERING

When the mechanical work has been completed, a start may be made with populating the board. Since the *LCR* meter is not intended for beginners, it is assumed that you are well versed in soldering. Nevertheless, there are some points which should be specially noted.

Sockets PC_1–PC_4 must be fastened with small self-tapping screws before any solder connections are made to them.

The crystals must be fixed into position so that they float about 1 mm above the board; this prevents any risk of their metal case causing a short-circuit between adjacent tracks on the board.

In a similar manner, but for a different reason, regulators IC_{13} and IC_{14} must, after their terminals have been bent at right angles, be suspended above the board with the aid of 5 mm long plastic or nylon round clearance spacers. This enhances their air cooling.

Test resistors R_7 and R_8 should be fitted last on to the board. This is because the less they are exposed to mechanical stress and heating, the better their stability will remain.

All other components may be fitted in the usual way. It is advisable, but not necessary, to use sockets for the ICs.

Solder a 4-pin section of a single-row IC socket to the section of board for switches S_1–S_3. Before any soldering, cut the pins of the IC socket short so that they do not protrude at the component side of the board and do not touch S_2 when this is pressed. Fit the switches with protective caps as specified so that they do not interfere with one another when they are pressed.

Link terminals 17–20 of connector K_2 to the switch-board via K_3 and terminals 1–16 to the display via a 10–15 cm long piece of 20-way flat-cable.

In the specified Seiko display module, the terminals for the backlight are isolated from the data terminals (as, indeed, in most displays). Pin 16 of K_2 is connected to the earth terminal of the backlight and pin 15 to the supply terminal. These terminals are normally identified by + or C (for cathode) and – or A (for anode) respectively. The remaining terminals (1–14) of K_2 are linked to the corresponding terminals on the display.

Fit the display and the switch-board to the plastic front panel (**Figure 7**). Use countersunk M2 screws for

Figure 5b. Track layout of the printed-circuit board for the LCR meter.

DIY Test Adaptor

A four-wire test is conveniently carried out with the aid of the test adaptor shown in this box. The outer pins provide the current through the component on test, while the inner pins are used to measure a voltage (drop). With a little dexterity and suitable tools (4-mm tap, a set of standard size steel drills and a metal saw), the adaptor is easily made in a home workshop. It is made from two strips of brass, 10 mm long, 2 mm thick and a strip of polythene (or plastic or nylon).

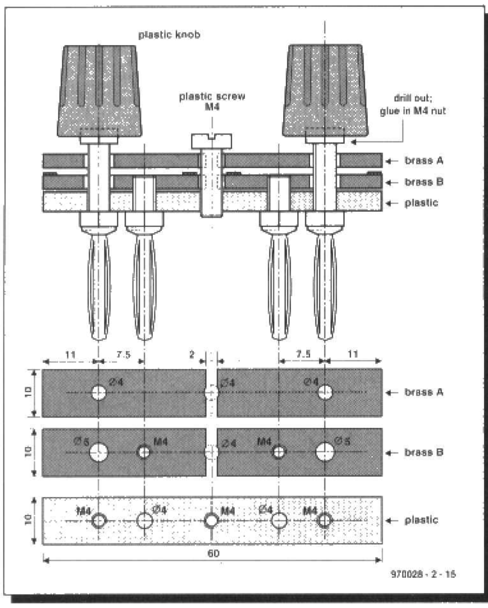
The construction drawing shows that the inner pins are electrically linked to the lower brass strip, whereas the outer pins are connected to the upper brass strip. The polythene strip functions as the carrier: a nylon M4 size screw ensures that the strips stay firmly together.

When the three strips have been cut to size, clamp them in a vice (edge-ways in the jaws) and drill the five 3.2 mm holes right through. Remove the strips from the vice and tap the holes where indicated. Holes that need not be tapped should be reamed or drilled out to 4 mm diameter.

Cut the thread of the inner pins to the requisite length and use them to fix the lower brass strip to the polythene strip. The remainder of the work is evident from the drawing.

Cut the nylon fixing screw at the centre to a length that allows a gap of not more than 2–4 mm between the two brass strips. Glue some thin felt pads between the brass strips where indicated.

The last operation is to fit an M4-size nut in each of the solid polythene knobs. Ream out the hole in the knob to such a depth that the nut just protrudes from the knob. This ensures good electrical contact between the brass strip and the screw when this is tightened. Finally, secure the nut with a drop or two of araldite or superglue.



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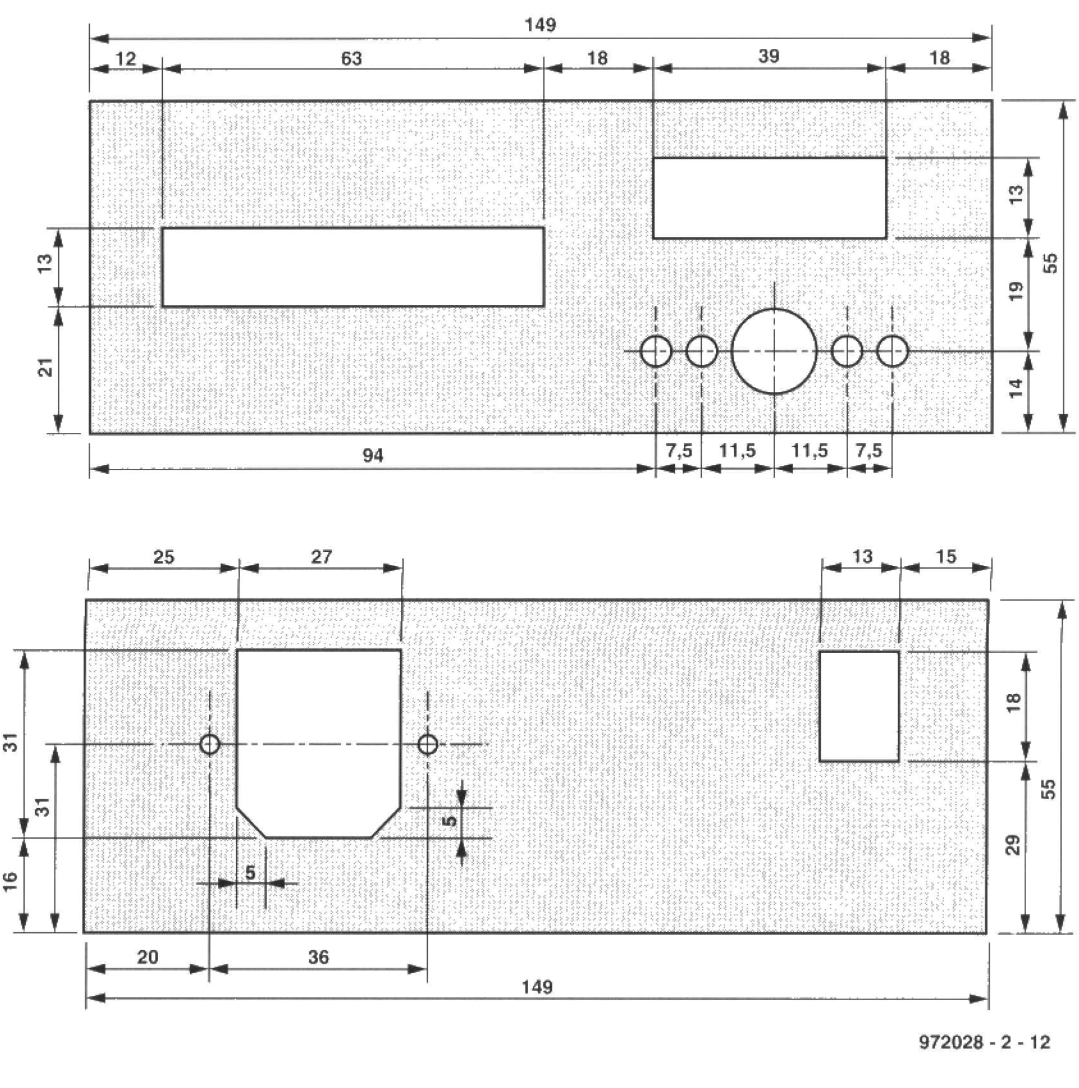
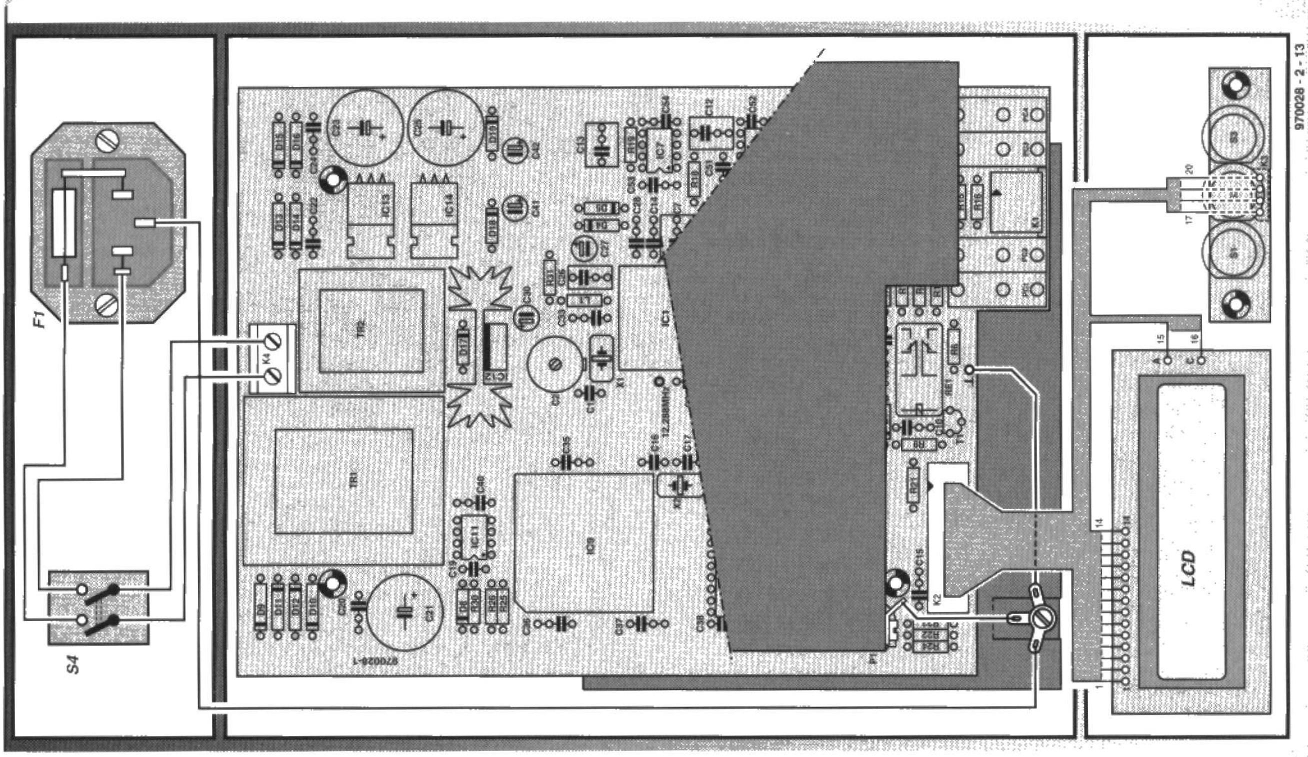


Figure 7. Templates for the front and rear panels of the enclosure. The display as well as the switch-board must be fitted with countersunk screws.

8 **Figure 8. Inter-wiring diagram for the LCR meter.**



the display and secure them with a drop of araldite or superglue. Use countersunk M3 size screws for the switch-board. It is important that the distance between this board and the front panel is determined by 5 mm long round clearance spacers and nuts in such a way that the knobs of the switches are level with panel. Lastly, fix the front panel foil, if used, into place.

Make appropriate cut-outs for the mains inlet and on/off switch in the rear panel (**Figure 7**) and fit these parts. The wiring diagram in **Figure 8** shows how the various interconnections are made.

MORE SCREENING

Like the lower half of the enclosure, the upper half must also be screened to minimize the effects of any external stray fields. This is accomplished by a sheet of 0.5 mm thick tin-plate cut to the size and shape shown in **Figure 9**. Bend the screen along the lines indicated. Place it into the upper half of the enclosure and fix it in place with two small self-tapping screws at the sides. The screen must be earthed with the aid of a solder tag secured with a small self-tapping screw at the front of the screen.

Make sure that the metal screens cannot touch the metal parts of the LCD. If this should happen, the digital and analogue grounds of the circuit would be linked which would adversely affect the accuracy of the instrument.

Note the importance of proper earthing of the instrument to the mains earth—see Figure 8.

This completes the construction of the instrument—Part 3 in next month's issue will deal with the calibration and the software. [970028-2

ELEKTOR		
240V ~	50Hz	
No. 970028		
P = 5 VA		

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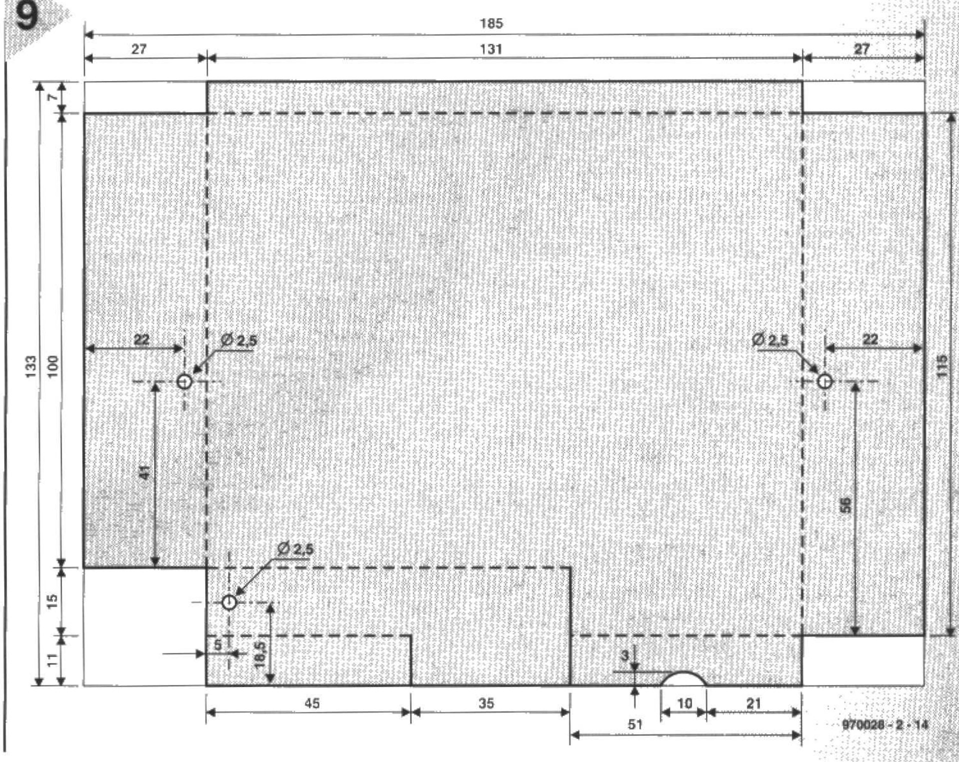
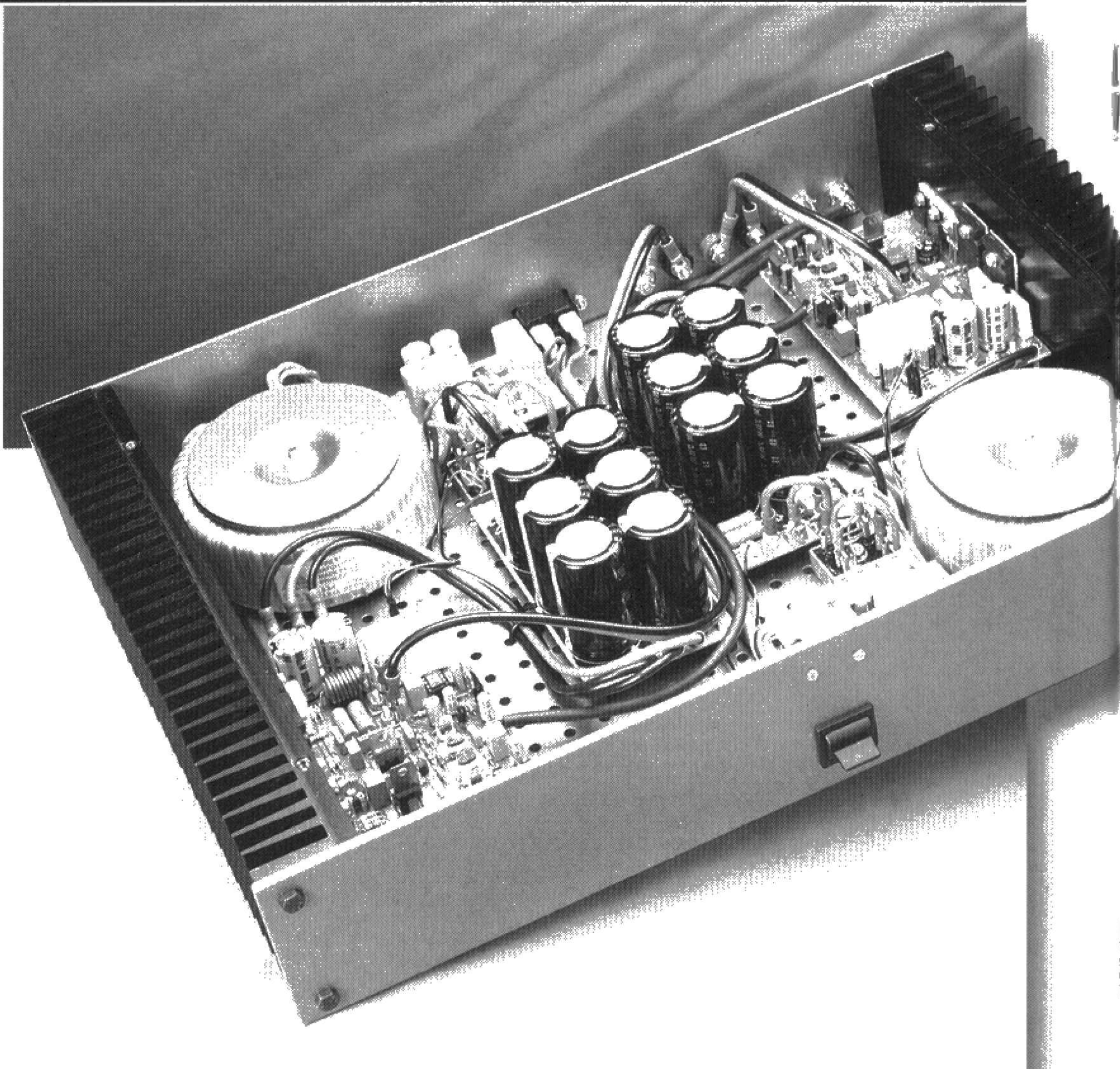


Figure 9. The template for the screen for the upper half of the enclosure shows the bending lines, the cut-outs and the three holes to be drilled.

compact power amplifier

Fast high-end design



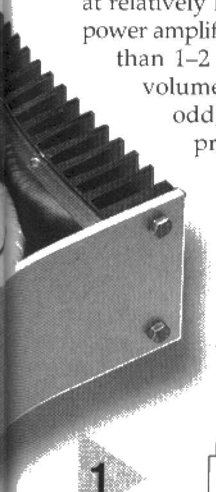
The battery-powered preamplifier published in our February 1997 issue must have made many of our readers long for a matching power amplifier. Odd as it may seem, it is almost two years ago that we last published a high-end power amplifier. This realization prompted the present compact power amplifier whose quality and layout match those of the preamplifier. It offers medium power output, is not overly complex and has a very high slew rate.

Design by T. Giesberts

The introduction gives a good idea of the power amplifier described in this article.

The term 'compact' refers to both the power output and the dimensions of the amplifier. Of course, compactness is a relative term, because the amplifier contains no fewer than 19 transistors. Over the years, compactness has taken on a different meaning than, say, ten years ago. Then, a compact amplifier was understood to contain not more than eight to ten transistors; today this figure is nearer to twenty-five. After all, as everybody now realizes only too well, quality always has its price.

As far as output power is concerned, the present amplifier is definitely intended for normal domestic use. It produces some 50 watts into 8 Ω or 85 watts into 4 Ω, which is more than ample for its intended use. Even at relatively high volume, a domestic power amplifier seldom provides more than 1–2 power output. To high-volume freaks it may sound odd, but most loudspeakers produce a sound pressure of about 90 dB at a distance of 1 metre for an input of only 1–2 watts—enough to make the neighbours rush for the telephone.



It is clear, therefore, that the present amplifier has more than ample reserve to reproduce even the highest peaks in a piece of music without any discernible distortion.

A further benefit of the circuit is the use of such a relatively high quiescent current that with power outputs up to 2.5 W the amplifier operates in Class A, which enhances the overall quality of the reproduced sound.

There are some other aspects which will be reverted to in detail later. Firstly, the power output is produced by two insulated gate bipolar transistors (IGBTs). These bipolar MOSFETs or, if you prefer, gate-controlled transistors have been used in power amplifiers published by us before.

Secondly, the amplifier uses current feedback instead of the more usual voltage feedback. This has a beneficial effect on the open-loop bandwidth, the power bandwidth and the slew rate.

Thirdly, as may be seen from the technical data, the figures for harmonic distortion, intermodulation distortion and the damping factor are very good, indeed. They make it clear that although the amplifier is small in size, it is large in performance.

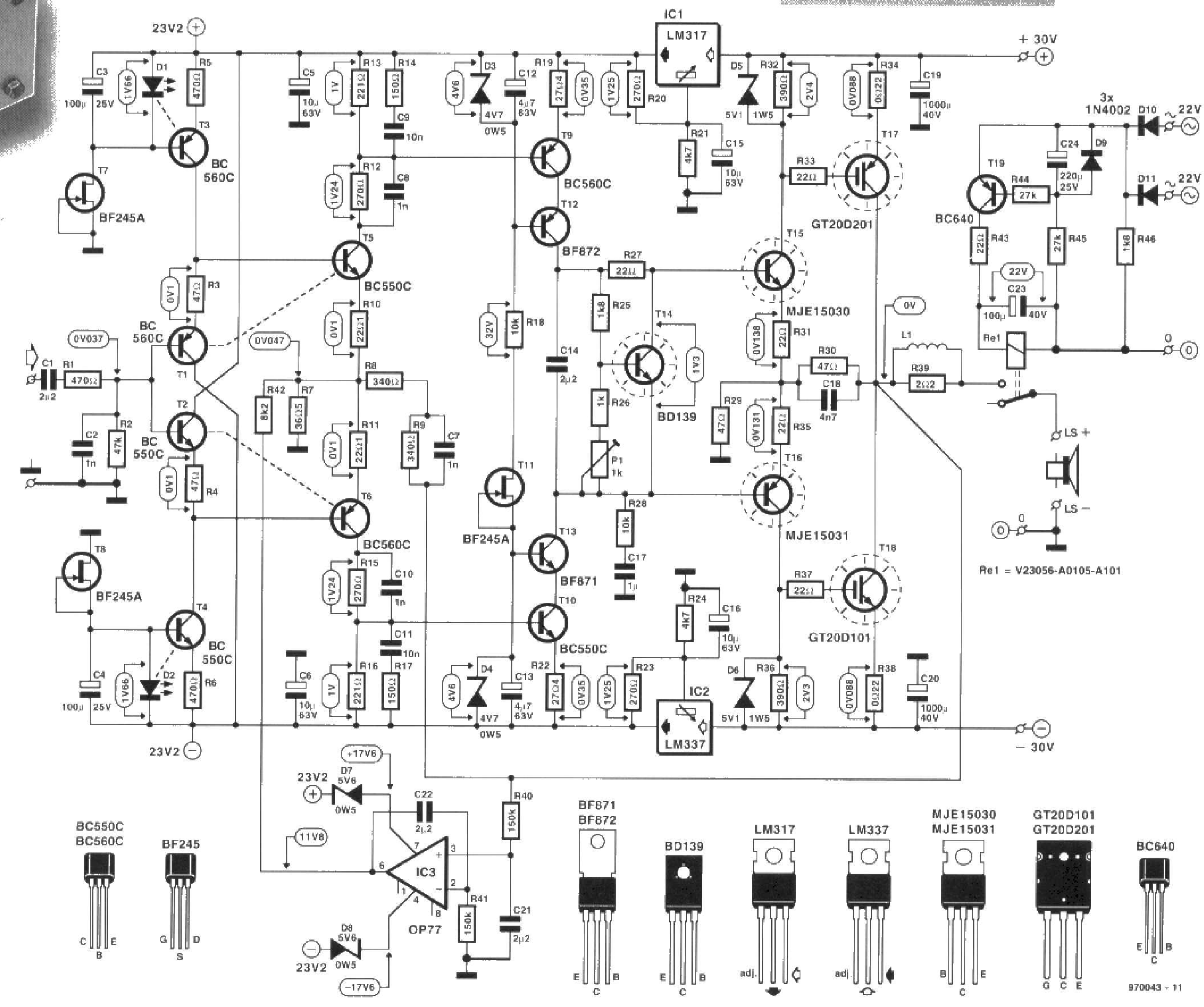
THE DESIGN

Experts in audio amplifier technology, as well as many other knowledgeable constructors, will see from **Figure 1** that in some respects the design of the power amplifier is different from the usual arrangement.

To start with, the almost obligatory differential input amplifier is not there. In its stead there is a symmetrical input stage that has some resemblance to the buffer stage used at the input of

Figure 1. The most conspicuous aspect of the circuit diagram is the omission of the traditional differential amplifier at the input. The output stage is based on insulated gate bipolar transistors.

1



Technical data

Input sensitivity	*1 V r.m.s.*
Output impedance	*47.5 kΩ*
Output power (0.1% THD)	*50 W into 8 Ω; 85 W into 4 Ω*
Power bandwidth (25 W into 8 Ω)	*1.5 Hz–270 kHz*
Slew rate	*37 V μs^{-1}*
Signal-to-noise ratio (1 W into 8 Ω)	*107 dB (A-weighted)*
	102 dB (B = 22 kHz linear)
Total harmonic distortion (B = 80 kHz)	
1 W into 8 Ω	*0.0015% (1 kHz)*
25 W into 8 Ω	*0.0025% (1 kHz)*
	0.008% (20 kHz)
Intermodulation distortion (50 Hz:7 kHz = 4:1)	
1 W into 8 Ω	*0.0025%*
25 W into 8 Ω	*0.008%*
Dynamic intermodulation distortion	
(Square wave 3.15 kHz, sine wave 15 kHz)	
1 W into 8 Ω	*0.002%*
25 W into 8 Ω	*0.002%*
Damping factor (8 Ω)	*700 (1 kHz)*
	450 (20 kHz)
Open-loop parameters (R_8 open)	
Amplification	*×2500*
Bandwidth	*40 kHz*
Output impedance	*0.3 Ω*

These data show the excellent performance of the power amplifier; exceptionally good are the power bandwidth and the slew rate. Some audio enthusiasts feel that performance data should be taken with a pinch of salt and that the important thing is a hearing test. This is not an opinion shared by this magazine. It is true that figures do not reveal everything, but it is surely admitted by all that poor data point to properties that cannot have a beneficial effect on the sound quality.

As usual, the data are accompanied by a number of curves obtained with an Audio Precision Analyser.

***Curves A** show the total harmonic distortion (THD+N) between 20 Hz and 20 kHz. The upper curve refers to 25 W into 8 Ω, and the lower to 1 W into 8 Ω. Both curves show an exemplary performance; note that the usual increase in distortion at high frequencies is small.*

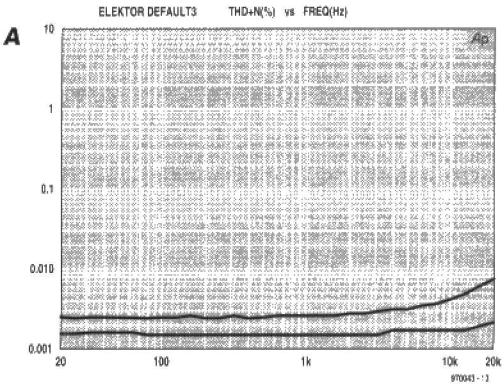
***Curve B** illustrates the distortion at 1 kHz as a function of the drive power over a bandwidth of 22 Hz to 22 kHz. The slight increase above about 2.5 W shows that from that point on the amplifier no longer operates in Class A. The clipping point is at 50 kHz.*

***Curves C** refer to the output power of the amplifier as a function of frequency with a load of 4 Ω and 8 Ω respectively.*

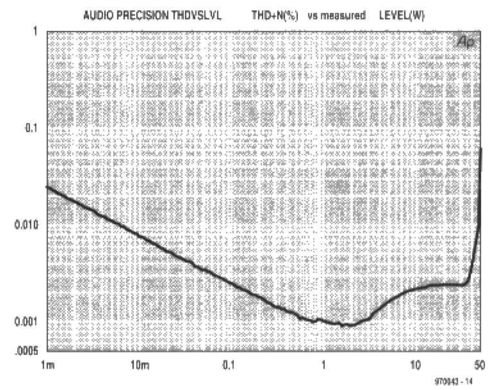
***Curve D** illustrates a Fourier analysis of a 1 kHz signal for an output of 1 W into 8 Ω. Although the 2nd and 3rd harmonics are clearly visible, their levels at –105 dB and –122 dB are well below that of the fundamental. All other harmonics remain below the noise floor.*

Listening tests showed the very good performance of the power amplifier even better than the technical data. The sound reproduction was very pleasant with good presence and transparent high-frequency performance that never became sharp. Low-frequency performance, both with classical and popular music, remained remarkably taut. The amplifier held the loudspeakers in an iron grip as it were and never relinquished control.

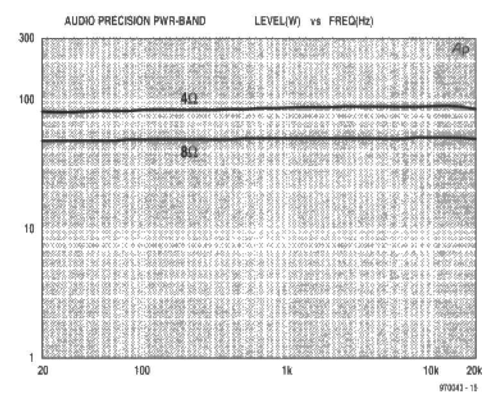
A



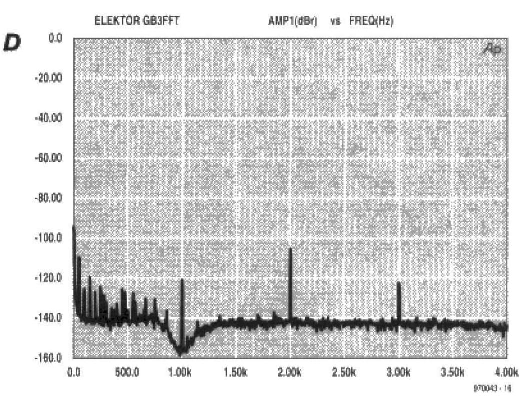
B



C



D



the battery-operated preamplifier.

In combination with current feedback this results in an amplifier that is appreciably faster than one with the traditional differential input stage.

The power amplifier has an open-loop bandwidth of some 40 kHz at the relative low amplification of ×2500. This enables the overall feedback, which many enthusiasts do not like, to be kept to a quite conservative level.

There is another side to everything and current feedback is no exception. A well-known but unavoidable drawback is the poor common-mode and supply-line suppression. In the present design, the effects of these have been countered to a large extent, however, by the use of two regulators in the power lines to all voltage amplifiers. This, in turn, has the drawback that the level of the supply voltage to these amplifiers is lower than that to the current amplifiers, although it should really be higher. This limits the maximum drive, but that is compensated by making the current amplifiers

amplify ×2. Because of this, the output stage is not arranged as the usual emitter follower, but rather as a compound configuration.

Output transistors T_{17} and T_{18} are, as mentioned earlier, insulated gate bipolar types. These may be considered as transistors with a MOSFET input, which has the advantage of requiring a smaller current from the drivers, T_{15} and T_{16}. As this results in lower loading of the local feedback loop, it. means that the amplification of the drivers can be higher, which enhances the linearity of the current amplifiers.

INPUT STAGE

The input stage of the amplifier consists of emitter followers T_1 and T_2 and symmetrical voltage amplifiers T_5 and T_6 (**Figure 1**). Current feedback is obtained by coupling the output of the power amplifier to the emitters of T_5 and T_6.

The emitter followers provide impedance matching and arrange the base bias of T_5 and T_6. This arrangement relies on the fact that the drop across R_{10} and R_{11} is virtually the same as that across R_3 and R_4. The potential across the latter two resistors is held constant by current sources T_3 and T_4. Moreover, the reference voltages for these current sources are provided by D_1 and D_2, the current through which in turn is held constant by current sources T_7 and T_8.

To prevent the operating levels being upset by temperature effects in spite of these measures, T_5 and T_6 are thermally coupled to T_1 and T_2, while D_1 and D_2 are thermally coupled to current sources T_3 and T_4.

For best performance, it is advisable to select transistors T_1 and T_2 on the basis of equal base-emitter voltage and current amplification, but make sure that the (offset) potential across R_2 <50 mV. Since complete symmetry is virtually unattainable, there will always be some offset which is why the circuit based on IC_3 has been added. This stage compensates the input offset by placing an identical potential at feedback junction R_{10}-R_{11}. This will be reverted to later.

Combinations R_{14}-C_9 and R_{17}-C_{11} are compensating networks, while C_8 and C_{10} minimize the effects of the parasitic capacitances of T_5 and T_6.

VOLTAGE AMPLIFIERS AND OUTPUT STAGE

Voltage amplifiers T_5 and T_6 drive a push-pull amplifier based on T_9–T_{13}, which is arranged as a cascode stage for the following reasons. Firstly, such an arrangement limits the potential across, and the dissipation of, the actual voltage amplifier T_9-T_{10}. Secondly, a cascode configuration is ideal for obtaining high amplification coupled with a large bandwidth.

The d.c. operating point of the voltage amplifier is held stable by zener diodes D_3 and D_4, the current through which is in turn held constant by current source T_{11}.

The voltage amplifiers are loaded by the input impedance of T_{15}-T_{16}. Since this varies in accord with the output current of the power amplifier, it is linearized by resistor R_{28}. Capacitor C_{17} prevents any direct voltage from reaching the base of T_{16}.

The circuit based on T_{14} forms a temperature-independent transistor zener which has become a familiar aspect in many power amplifiers. This transistor is mounted on the heat sink adjacent to output transistors T_{17} and T_{18} and stabilizes the quiescent current through these devices. The level of this current is set with P_1.

Resistor R_{27} provides the additional negative temperature coefficient needed to compensate the time delay and thermal decay in the heat sink.

The output of the voltage amplifiers is applied to current amplifier T_{15}–T_{18}. Strictly speaking, this is a compound rather than a current amplifier, since, apart from current amplification, it also provides voltage amplification. The voltage gain (×2) is determined by resistors R_{29} and R_{30}; capacitor C_{18} serves to improve the response of the stage.

Since in a compound amplifier the collectors of the driver transistors form the output of the current amplifier, the gate-emitter potential does not influence the maximum drive from the voltage amplifier. This is an important benefit, because the gate-emitter potential may be several volts. The only limiting factor in the present amplifier, is, therefore, the knee voltage of T_{17} and T_{18}.

Emitter resistors R_{34} and R_{38} are low-inductance types to prevent any tendency to oscillation or other spurious effects.

Inductance L_1 wound on R_{39} enhances the performance of the power amplifier when the load is capacitive.

Zener diodes D_5 and D_6 protect the gates of T_{17} and T_{18} against overdrive.

In operation, the temperature of drivers T_{15} and T_{16} strongly affects the setting of the quiescent current. So as to make the power amplifier as stable with temperature variations as feasible, these transistors are, therefore, also mounted on the same heat sink as T_{14}, T_{17} and T_{18}. While it is true that the quiescent current will always vary to some (small) degree with temperature, the thermal coupling of the various transistors ensures that any drift is well within acceptable limits.

MISCELLANEOUS ASPECTS

So as to keep the power amplifier as compact as possible, it does not contain elaborate protection circuits.There is, however, a power-on delay to suppress annoying clicks and plops at on and off switching. Delayed on/off switching of the power lines is effected by relay Re_1. To avoid any noise on the signal paths via the supply lines, the relay has independent power lines. For this purpose, D_{10} and D_{11} rectify the secondary voltage of the mains transformer. The resulting direct voltage is buffered by C_{23} which ensures that the energizing voltage for the relay is 22–24 V.

After the power has been switched on, T_{19} begins to conduct slowly via R_{44}-R_{45}-C_{24}. It takes a few seconds before this transistor is fully on: only then will the relay be energized. When the power is switched off, C_{24} is rapidly discharged via R_{46} so that the relay is deenergized without any discernible delay.

To aid the offset setting, IC_3 compares the output of low-pass filter R_{40}-C_{21} with the direct voltage at the output of the power amplifier. If there is a difference, the operating point of T_5-T_6 is adjusted via R_{42} in such a manner that the average output of the power amplifier remains at earth potential. This arrangement ensures that the offset voltage at the output cannot exceed that of IC_3 ($\leq 100\,\mu V$ at 25 °C). It is a fact, however, that tiny variations caused by temperature changes cannot be eliminated entirely.

Zener diodes D_7 and D_8 reduce the supply voltage of ±23.2 V to the requisite level for IC_3.

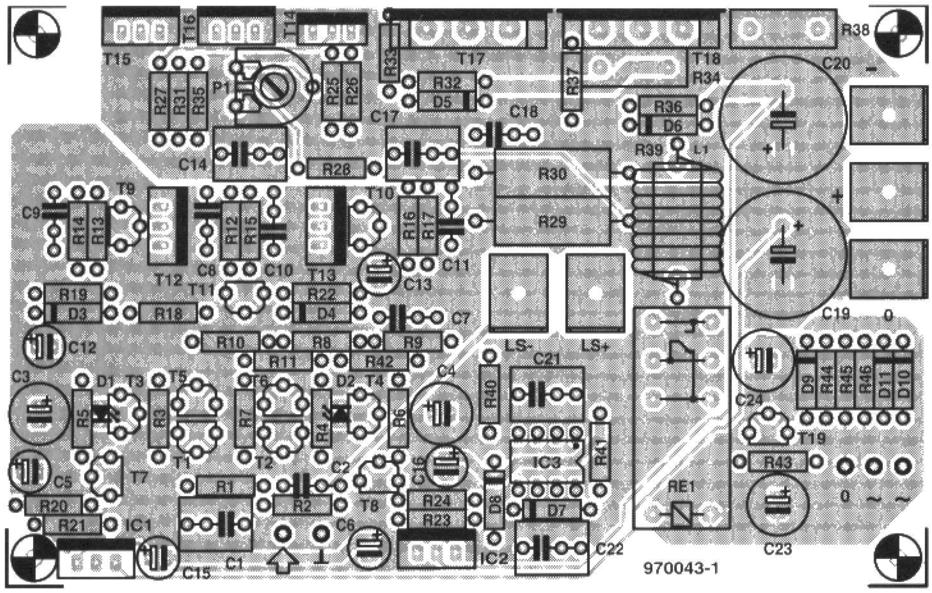
The reasons for regulation of the supply lines to the input and voltage amplifiers has already been mentioned. The regulation is provided by IC_1 and IC_2. Type LM317 and LM337 respectively have been used for these regulators because they provide very good ripple suppression and tolerate a high peak input voltage. A further advantage of them is that their output potential can be adjusted very accurately by means of resistors R_{20}-R_{21} and R_{23}-R_{24} respectively. Capacitors C_{15} and C_{16} increase the ripple suppression to 70–80 dB.

CONSTRUCTION

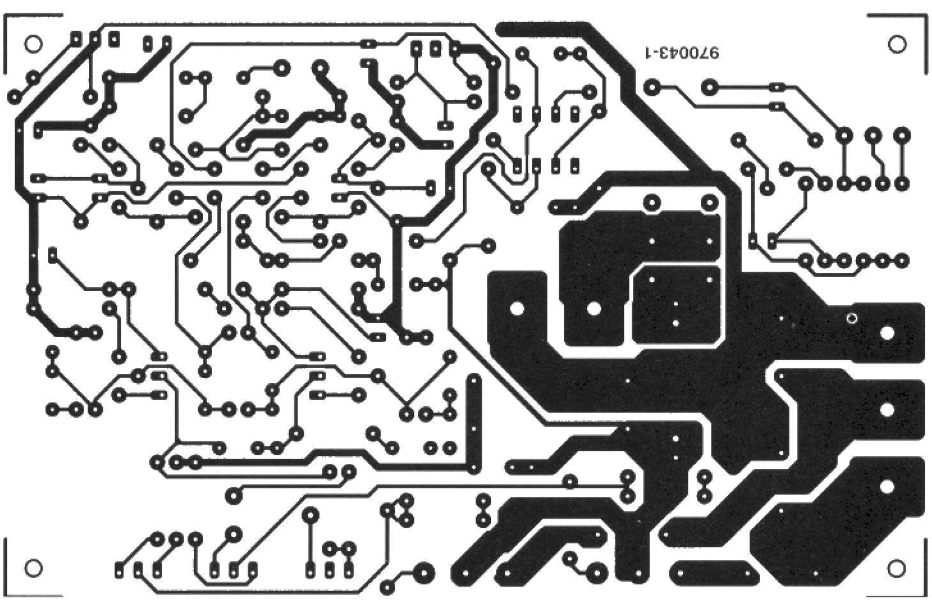
The power amplifier is best built on the double-sided printed-circuit board shown in **Figure** 2. Making the board double-sided meant that it could be made very compact without the necessity of (too) long copper tracks at essential locations. The layout is unambiguous so that population of the board is straightforward.

Transistors T_{14}-T_{18} are located neatly in a row at one side of the board to facilitate their fixing on to the

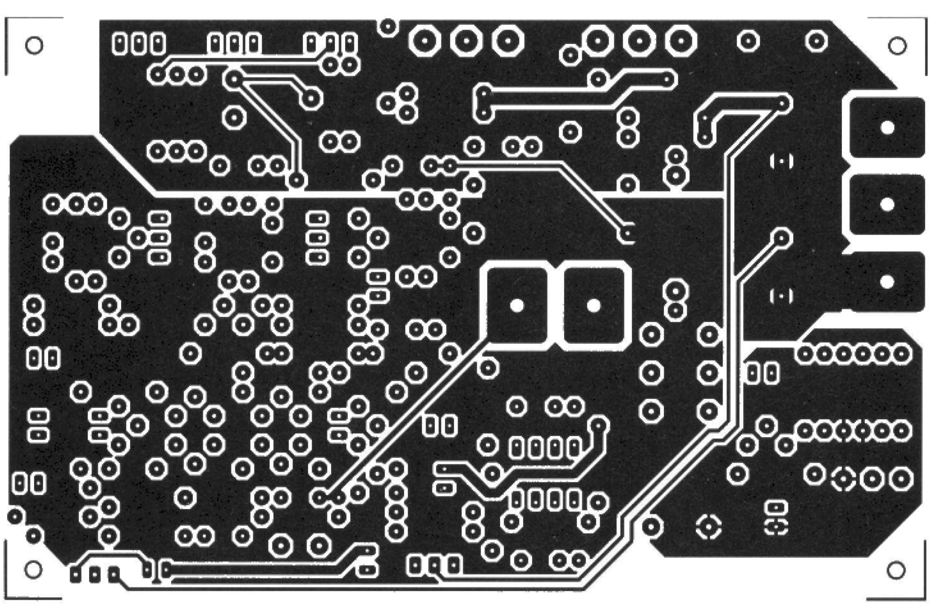
Figure 2. The double-sided printed-circuit board for the power amplifier. Large currents flow over only a few tracks.



solder side



component side



Parts list

Resistors:
R_1, R_5, R_6 = 470 Ω
R_2 = 47 kΩ
R_3, R_4 = 47 Ω
R_7 = 36.5 Ω, 1%
R_8, R_9 = 340 Ω, 1%
R_{10}, R_{11} = 22.1 Ω, 1%
R_{12}, R_{15}, R_{20}, R_{23} = 270 Ω
R_{13}, R_{16} = 221 Ω, 1%
R_{14}, R_{17} = 150 Ω
R_{18}, R_{28} = 10 kΩ
R_{19}, R_{22} = 27.4 Ω, 1%
R_{21}, R_{24} = 4.7 kΩ
R_{25}, R_{46} = 1.8 kΩ
R_{26} = 1 kΩ
R_{27}, R_{31}, R_{33}, R_{35}, R_{37}, R_{43} = 22 Ω
R_{29}, R_{30} = 47 Ω, 5 W
R_{32}, R_{36} = 390 Ω
R_{34}, R_{38} = 0.22 Ω, 5 W, low inductance
R_{39} = 2.2 Ω, 5 W
R_{40}, R_{41} = 150 kΩ
R_{42} = 8.2 kΩ
R_{44}, R_{45} = 27 kΩ
P_1 = 1 kΩ preset

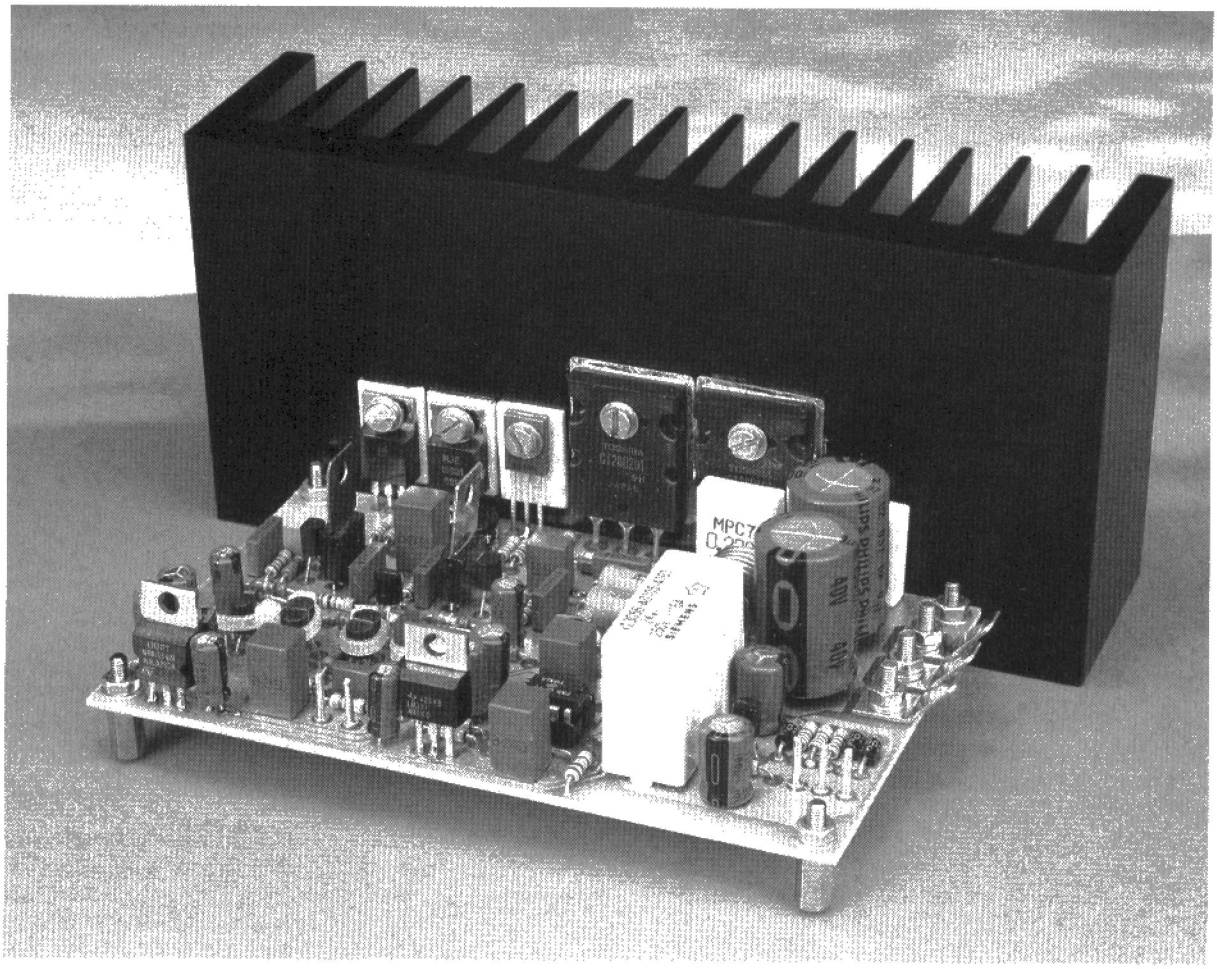
Capacitors:
C_1, C_{14}, C_{21}, C_{22} = 2.2 μF metallized polyester, pitch 5 or 7.5 mm
C_2, C_7, C_8, C_{10} = 1 nF
C_3, C_4 = 100 μF, 25 V
C_5, C_6, C_{15}, C_{16} = 10 μF, 16 V, radial
C_9, C_{11} = 10 nF
C_{17} = 1 μF, metallized polyester, pitch 5 or 7.5 mm
C_{18} = 4.7 nF
C_{19}, C_{20} = 1000 μF, 40 V, radial
C_{23} = 100 μF, 40 V, radial
C_{24} = 220 μF, 25 V, radial

Semiconductors:
D_1, D_2 = LED, 5 mm, flat
D_3, D_4 = zener diode, 4.7 V, 500 mW
D_5, D_6 = zener diode, 5.1 V, 1.5 W
D_7, D_8 = zener diode, 5.6 V, 500 mW
D_9–D_{11} = 1N4002
T_1, T_3, T_6, T_9, =BC560C
T_2, T_4, T_5, T_{10} = BC550C
T_7, T_8, T_{11} = BF245A
T_{12} = BF872
T_{13} = BF871
T_{14} = BD139
T_{15} = MJE15030 (Motorola)
T_{16} = MJE15031 (Motorola)
T_{17} = GT20D201 (Toshiba)
T_{18} = GT20D101 (Toshiba)
T_{19} = BC640

Integrated circuits:
IC_1 = LM317T
IC_2 = LM337T
IC_3 = OP77 (Analog Devices)

Miscellaneous:
L_1 = see text
Re_1 = relay, 24 V, 875 Ω with single make contact 16 A, 250 V, e.g. Siemens Type V23056-A0105-A101
5 off PCB mounting flat 3-way sockets
Heat sink 1.2 K W^{-1} or smaller – see text; e.g. Fischer SK85SA/75 mm from Dau (telephone 01243 553 031)
Insulating washer and insulating bushes for T_{14}–T_{18}
PCB Order No. 970043 – see Readers Services towards the end of this issue

3



heat sink. They must, of course, be electrically isolated from each other with the aid of insulating washers and bushes for the fixing screws. In view of the required temperature stability, it is advisable to keep the terminals of T_{14} as long as possible to ensure that the device, when mounted, is at about the same height as the centre of T_{17}. This makes for good thermal coupling.

The other semiconductors and integrated circuits do not need extra cooling.

As mentioned earlier, good thermal coupling of a number of components (T_1-T_5; T_2-T_6; D_1-T_3; and D_2-T_4) in the input stages is also imperative for good performance. The easiest way of ensuring this is to secure the various pairs of components together with cable ties. In the case of D_1-T_3 and D_2-T_4 this is possible only if flat diodes are used. Tie the pairs together before fitting and soldering them on to the board. Mind the orientation of the diodes. It is advisable to mark the transistors with n-p-n or p-n-p, as the case may be, so that it is clear at a later stage which pair is which.

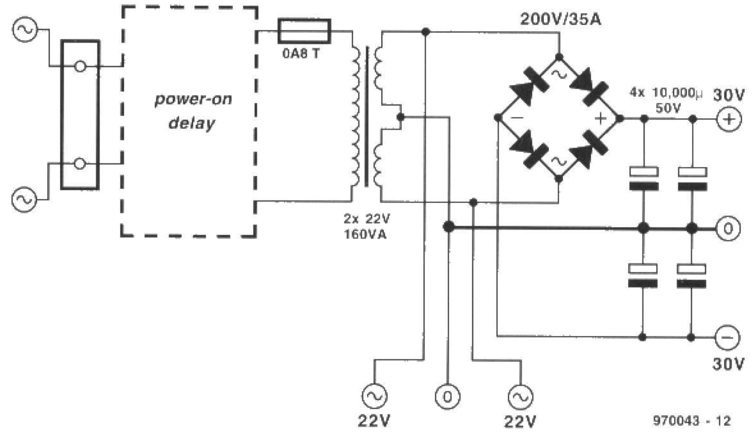
Inductor L_1 consists of eight turns of 1.5 mm dia. enamelled copper wire wound around a 9 mm drill bit. When it is wound, withdraw the drill bit, insert R_{39} into the coil and fit and solder the assembly on to the board at a height of a few millimetres above the surface.

All connections that carry large currents are output via PCB mounting flat sockets. The power connections are at the middle of one side of the board marked LS+ and LS–. The power lines to the relay are connected via ordinary

Figure 3. Photograph of the completed prototype board with heat sink. Two- and three-pin flat PCB mounting connectors are used for the loudspeaker and power line connections.

Figure 4. The power supply may be kept simple, but should have ample reserve power. Note that the diagram shows a design for a mono power amplifier.

4



Suggested power supply (for mono amplifier):
Toroidal mains transformer, secondary 2×22 V, 160 VA
Bridge rectifier 200 V, 35 A
4 off electrolytic capacitor 10,000 µF, 50 V
Fuse holder and fuse 800 mA, slow

board terminals. Note that these lines consist of three wires: this means that the earth line must NOT linked to the amplifier earth.

The completed board with heat sink is shown in **Figure 3**. The heat sink must have a thermal resistance of 1.2 K W^{-1} or smaller.

POWER SUPPLY AND QUIESCENT CURRENT

When the board has been completed and thoroughly inspected for any faulty workmanship (including a one-by-one check of the components against the part list), a few operational tests need to be carried out. Naturally, a power supply is needed and a suitable arrangement for this is shown in **Figure 4**. This is a traditional setup of power-on delay, mains transformer, with a 2×22 V, 160 VA secondary, a 35 A bridge rectifier and four 10,000 μF electrolytic reservoir capacitors. This supply provides sufficient current even when 4 Ω loudspeakers are used. Note that the diagram is for a supply for a mono amplifier: two are needed for a stereo amplifier.

The diagram also shows how the power lines for the relay are obtained.

The power-on section is advisable but not obligatory. It serves to prevent large current peaks during switch-on.

As in all power supplies, good, firm, well-soldered connections are of prime importance. They ensure that there is no unnecessary resistance in the path of large currents.

Before the power is switched on, it is vital that preset P_1 on the power amplifier is turned completely anti-clockwise. If this is not done, there is a risk that the quiescent current through the output transistors quickly reaches a very high level and the circuit is not designed to cope with this.

After the power has been switched on, check with a multimeter whether the potentials at the output of IC_1 and IC_2 are as indicated on the circuit diagram in Figure 1 (±23.2 V respectively). Then, measure the output voltage of the amplifier, which must be 0 V or very nearly so. If it is not, recheck the entire construction, particularly the input stages.

When up to this point all is well and the LEDs light, it may be assumed that the entire power amplifier is in good working order. It is then time to check all the potentials at the test points indicated in Figure 1.

Next, set the quiescent current with P_1. This is fairly high in this power amplifier: about 400 mA when a heat sink as specified is used; if a heat sink of ≤ 0.6 K W^{-1} is used, the current may even be as high as 500 mA. Connect a millivoltmeter set to its 200 or 250 mV range across R_{34} or R_{38} and turn P_1 slowly clockwise until the meter reads 88 mV (current = 400 mA) or 110 mV (current = 500 mA).

Leave the amplifier to warm up thoroughly and then readjust P_1 as required.

ASSEMBLY

The design of the printed-circuit board is intended for its use as a mono amplifier. From a quality point of view, this is the best way of building an amplifier. Use a compact enclosure, perhaps with integral heat sink, and assemble board and power supply in this to make a stand-alone mono amplifier. A stereo amplifier is obtained by building two of these mono units and simply stacking them.

Wiring up the assembly is straightforward. Use heavy-duty wire for the +ve, –ve and earth supply lines and link them to the appropriate terminals on the board. Use heavy-duty wire also for linking the loudspeaker terminals with the LS+ and LS– PCB mounting 4 mm sockets on the board.

Link the phono input socket at the rear of the enclosure to the two input terminals on the board via a short length of screened audio cable.

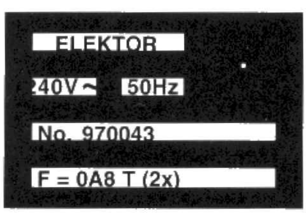
Next, link the two 22 V~ and 0 lines to the relay – remember that the 0 line must not be connected to the amplifier earth – see below.

The mains inlet should be of good quality, preferably with an integral fuse holder. The fuse rating is shown on the serial number label that should be affixed to the rear of the cabinet.

It is imperative that earth loops are avoided. This is best done by ensuring that there is link between the mains earth, the 0 supply line and the cabinet earth at only one point. Normally, and most conveniently this is at the signal input socket. If a non-insulated phono socket is used, this is automatically connected to the cabinet earth, so that no further action is needed.

It is, of course, possible to assemble two mono amplifiers using a single power supply in one cabinet, but this is not advisable. Even if it is desired to use only one cabinet, each of the mono amplifiers should have its own discrete power supply. The introductory photograph shows that this is how the prototype was constructed. The cabinet used for the prototype was provided with an integral heat sink and measured 445×75×305 mm (W×H×D).

[974003]



In passing ...

Most readers of this magazine know that it is published in identical form (at least as far as the articles are concerned) in Dutch, French and German, as well as in Greek, Polish, Portuguese, Spanish and Swedish in non-identical form. The Dutch, English, French and German issues are produced in the Netherlands, but published in the relevant country. These issues are the responsibility of an international team of writers/translators and technical editors.

On the face of it, there should be no problem in producing a supranational electronics magazine, since electronics is more international than any other branch of engineering. The electronics market is a world market: there is not one semiconductor or IC manufacturer who does not operate internationally. Also, norms and specifications tend to be internationally agreed.

Working in a multi-language team presents no real difficulties: most of the editorial staff have worked together for almost twenty years. Of course, technical translating is quite different from literary translating: for one, the technical translator has to know and understand the subject!

Most difficulties arise from the differences in standards laid down many years ago. For instance, an article on television will have to take into account that France (and eastern Germany) uses Secam, England PAL-I (but many other English-speaking countries NTSC), and Germany and the Netherlands PAL-B/G. The same applies to the different mains voltage outlets in the four countries. Astra transmissions are popular in Britain and in Germany, but not much in the Netherlands. Similarly, GSM mobile telephones for the E-band (1800 MHz) are in use in Britain and in Germany, but not in France and Holland.

Surprises still occur as well: chipboard or PVC tubing of the density specified in a German design are not available in the Netherlands. And Siemens products are not not easily available from retail outlets even in Germany. Strangest of all: try to find a bicycle rear light that is standard in all four countries!

[975043]

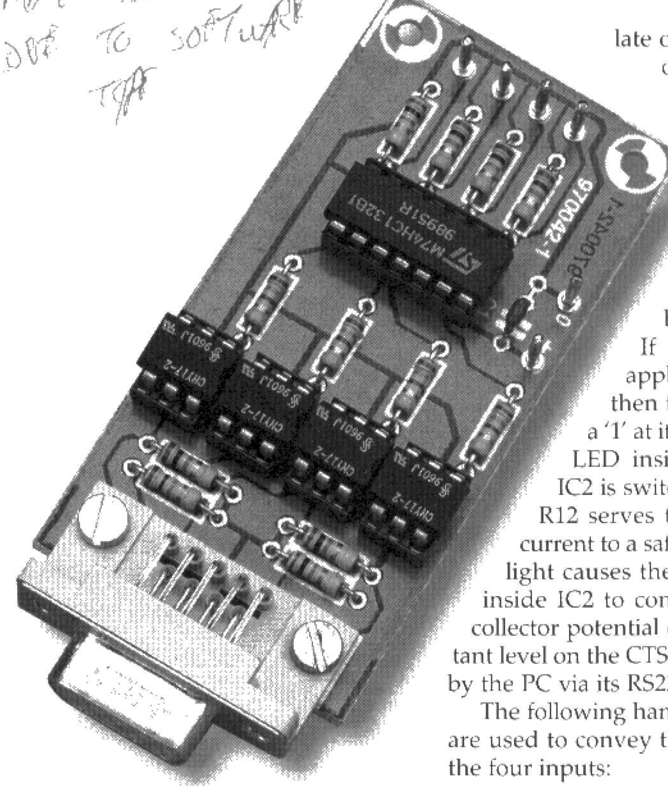
ERROR / CORRECTION
FROM ELEKTOR
JULY/AUG 1997
P. 53

4-channel logic analyser

MAY NOT WORK
DUE TO SOFTWARE
TJR

on a budget!

This is probably the simplest and cheapest logic analyser you have ever seen. A handful of inexpensive components in combination with a straightforward BASIC program enable you to check the logic state and correlation of up to four digital signals with a 5-volt swing.



When logic does not function in a logic way, or you don't understand the logic of it all, the best thing to do is take a deep breath and start analysing the individual components that make up a logic combination. No problem if you have an oscilloscope or, in some cases, a simple multimeter. Next, you have to look at how the various 'components', which will usually be digital signals, interact. And that's where the problems start because you do not have the requisite test equipment which displays the logic states in one go.

Logic analysers used to be confined to the realms of professional electronics design laboratories and repair stations. These instruments normally cost a small fortune, and are able to display tens of digital signals simultaneously at very high sampling frequencies. Yet, the basic elements lurking in these professional instruments are (1) logic level detectors, and (2) a common visualisation (display) device.

Look at the single star at the top of this page and you know that it is not our intention to mimic or even approach the operation of a professional logic analyser. Here, we'll make do with four channels, extremely simple hardware and a PC acting as the display device.

Design by A. Tüchter

Logic level detection

A logic level detector is required to be able to tell the difference between a logic 'high' level, also called '1', and a logic low level, or '0'. In nearly all of today's logic circuits, '0' means 0 V, and '1', +5 V, simply because the supply voltage is 5 V. That is theoretical, however, and most of you will know that these ideal levels are hardly ever encountered in practice.

The circuit diagram in **Figure 1** shows four identical converters which translate logic signals (0 or 1) into corresponding signals which can be read and processed by a PC. As all converters are identical, we may call them *channels*. Each of them consists of a Schmitt-trigger gate followed by an opto-isolator. Let's look at the top channel, whose input signal arrives on IC1a via input 1. The two Schmitt trigger gate inputs are held at 0 V by resistor R1. This is done to set a logic 0 on the channel when it is not used, and to ensure that the gate does not oscillate or produce spurious output signals. If a logic 1 is applied to input 1, a logic 0 appears at the output of the gate, because it inverts. If a logic 0 is applied, or no signal, then the gate supplies a '1' at its output, and the LED inside opto-isolator IC2 is switched on. Resistor R12 serves to limit the LED current to a safe value. The LED light causes the phototransistor inside IC2 to conduct, so that its collector potential drops. The resultant level on the CTS line may be read by the PC via its RS232 port.

The following handshaking signals are used to convey the logic levels at the four inputs:

Channel1:	*CTS (clear to send)*
Channel2:	*DSR (data set ready)*
Channel3:	*RI (ring indicator)*
Channel4:	*DCD (data carrier detect)*

The common positive supply voltage of about 10 V for the phototransistors is derived from the PC via the RxD line.

The PC is connected to K1 by means of a standard RS232 cable with 9 pins at both sides, and non-crossed wires.

The 5-V supply voltage for the 74HCT132 and the LEDs inside the opto-isolators has to be supplied externally. The maximum anticipated current consumption will be of the order of 75 mA when all four channels are at '0', and less than 0.5 μA when all channels are at '1'. This sort of current consumption is easily managed by a 7805 voltage regulator in its standard application circuit. Alternatively, you may obtain the 5-V supply voltage from the digital circuit under test.

The copper track layout and component mounting plan of the circuit board designed for the interface is shown in **Figure 2**. Unfortunately, this board is not available ready-made through our Readers Services. Construction is all plain sailing if you work carefully, and stick to the parts list and

the component overlay. Be sure to use a socket, **not** a plug-type (male), connector for K1.

THE PROGRAM

The program you have to run on your PC to visualize the logic state of the four input signals is given in **Figure 3**. It is written in GW-BASIC, and pretty straightforward. Even if you do not fancy building the hardware, the program is still worth examining if you are interested in learning how, say, an RS232 port is read using a simple language like BASIC.

The program and the hardware may be used on any PC having GW-BASIC and a free COM port. Even an old AT may be dusted off for use in this project. If you are not sure about the number of RS232 ports on the PC, use the BIOS setup to locate the ports and their addresses. In most cases, two ports will be available: COM1 at 3F8H, and COM2 at 2F8H. Check these addresses against those in line 6 of the program. Obviously, to avoid annoying problems with IRQ conflicts, you should choose a **free** COM port to attach the logic analyser hardware. If you don't fancy tweaking the BIOS settings in your computer, use Microsoft Diagnostics (MSD), a DOS program which will tell you the PC settings instantly.

The core of the program is formed by the routines which translate logic levels read from the RS232 port registers into an oscilloscope-like trace on the PC monitor. The screen layout has been kept as simple as possible to prevent distraction from the four logic level traces displayed in the centre.

The program starts by reading a number of variables which determine the operation of the software. These variables include w$ for the COM port number (1 through 4), k$ for the number of analyser channels (1 through 4), HCAdr for the COM port status register address (base+3, where base is 2F8, 3F8, 3E8 or 2E8), and meas$, which selects the sweep mode: continuous, single sweep or with pause. Remember, the program reads the status of four handshaking signals, RI, DCD, DSR and CTS, from the RS232 port register.

In the `*** draw measured signals ***` routine, the variable Cstate is evaluated to determine if a 'high' or a 'low' line has to be drawn in the timing diagram which appears on the screen. The reading of the variable takes place in a loop which checks all four channels. Once all four traces have been drawn on the screen, the program reads the sweep mode variable to determine how it continuous.

COMPONENTS LIST

Resistors:
R1-R8 = 10kΩ
R9-R12 = 150Ω

Capacitor:
C1 = 100nF

Semiconductors:
IC1 = 74HC132 (or 74HC00)
IC2-IC5 = CNY17-2

Miscellaneous:
K1 = 9-way sub-D socket, PCB mount, angled pins
6 solder pin

1

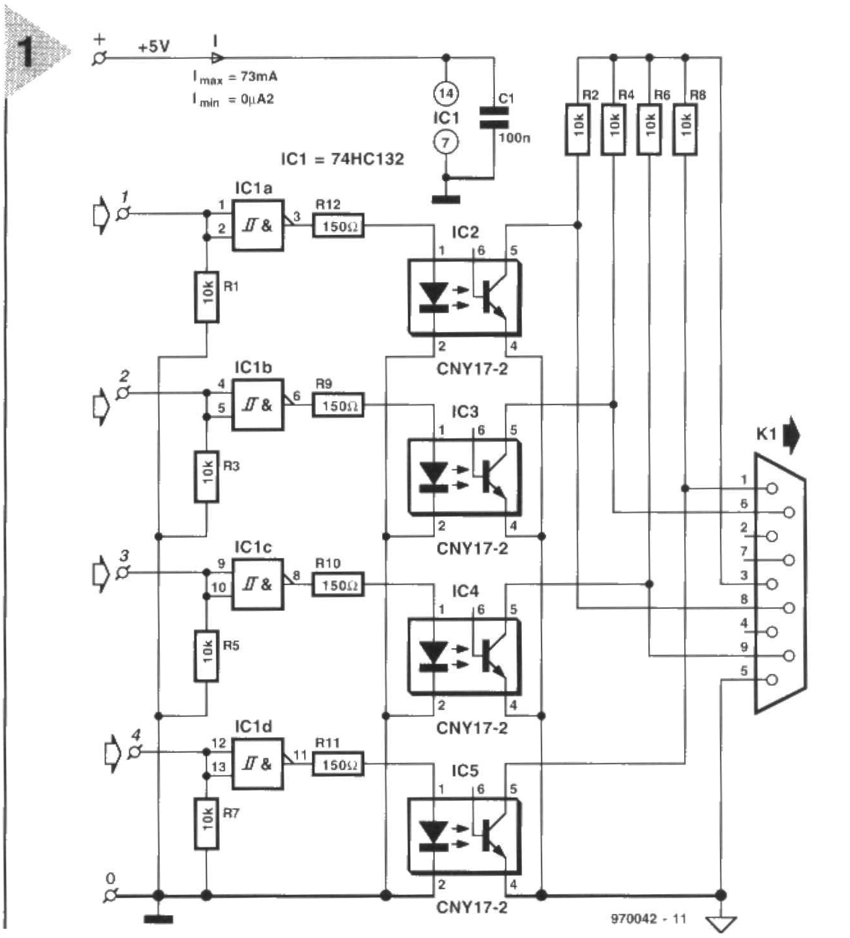
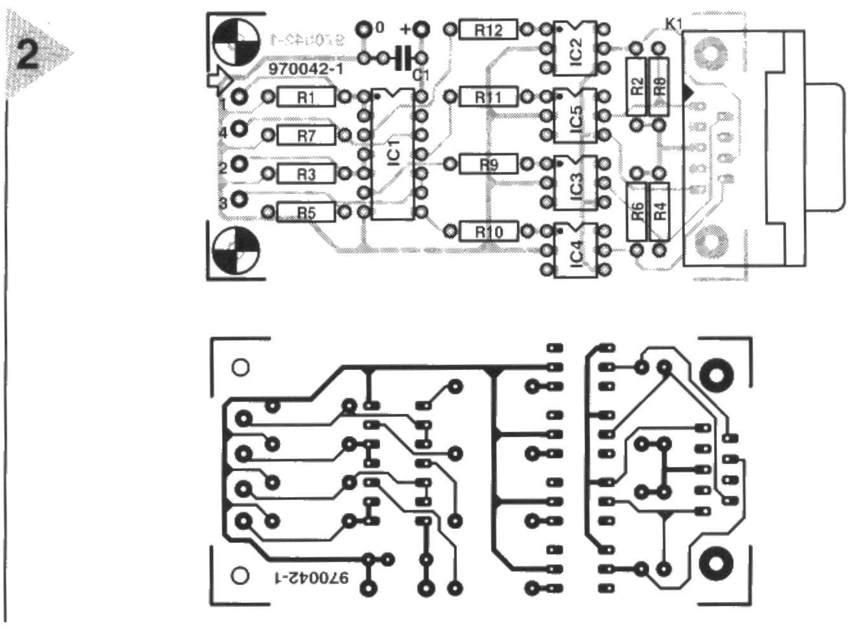


Figure 1. The logic analyser interface offers four electrically isolated input channels for 5-volt TTL logic.

Figure 2. PCB track layout and component mounting plan.

2



3

```
REM *****  Simple Logic Analyser using RS232
 *****
  CLS
CLEAR
    DIM CAdr(4), p(4, 3)
    CAdr(1) = &H3F8: CAdr(2) = &H2F8: CAdr(3) = &H3E8:
 CAdr(4) = &H2E8

REM ***** Declare subroutines for Keys <F1> and <F2> *****
KEY(1) ON: ON KEY(1) GOSUB f1
KEY(2) ON: ON KEY(2) GOSUB f2

REM ***** Write Logic Analyser logo to screen *****
PRINT
PRINT TAB(24); CHR$(201); STRING$(30, CHR$(205)); CHR$(187)
PRINT TAB(24); CHR$(186); STRING$(30, CHR$(32)); CHR$(186)
PRINT TAB(24); CHR$(186); "       PC - Logic Analyser
 "; CHR$(186)
PRINT TAB(24); CHR$(186); STRING$(30, CHR$(32)); CHR$(186)
PRINT TAB(24); CHR$(200); STRING$(30, CHR$(205)); CHR$(188)
LOCATE 25, 30
PRINT "<F1> Restart / <F2> End"; SPC(20);

REM *****     determine COM port   *****
LOCATE 10, 8
PRINT "COM port : (1) COM1  (2) COM2  (3) COM3  (4) COM4
 : ";
DO
  w$ = INKEY$
LOOP UNTIL (VAL(w$) < 5) AND (VAL(w$) > 0)
PRINT "COM"; w$

REM *****  Number of channels to use *****
LOCATE 12, 8
PRINT "Channels (1-4) : ";
DO:
  k$ = INKEY$
  Channel = VAL(k$)
LOOP UNTIL (Channel < 5) AND (Channel > 0)
PRINT Channel

REM ***** Sweep mode *****
LOCATE 14, 8
PRINT "Sweep mode: (C)ontinuous / (S)ingle sweep / (P)ause:
 ";
DO
  meas$ = UCASE$(INKEY$)
LOOP UNTIL meas$ = "C" OR meas$ = "S" OR meas$ = "P"
PRINT meas$

REM ***** Sample rate delay *****
DO
  LOCATE 16, 8
  INPUT "Delay (0 - 50.000) :", Delay
LOOP UNTIL (Delay >= 0) AND (Delay <= 50000)

HCAdr = CAdr(VAL(w$))
OUT HCAdr + 3, INP(HCAdr + 3) OR 64
FOR w = 1 TO Channel
  p(w, 1) = w * 80: p(w, 2) = (w * 80) - 50: p(w, 3) = w
 * 80
NEXT w

REM ***** Measurement *****
SCREEN 9
DO
CLS

REM ***** Draw X-axes and write additional text to screen
 *****
FOR w = 1 TO Channel
  LINE (0, w * 80)-(640, w * 80), 15, , 255
  p(w, 0) = 0
  COLOR w + 2, 0
  LOCATE 1, 1 + ((w - 1) * 10)
  PRINT "Channel"; w;
NEXT w
COLOR 15, 0
PRINT "com"; w$; "     Delay :"; Delay; " Sweep mode :";
 meas$
LOCATE 25, 30
PRINT "<F1> Restart / <F2> End"; SPC(20);

REM ***** Draw reference lines *****
FOR e = 1 TO 640 STEP 10
  LINE (e, 25)-(e, 320), 8, , 1024
NEXT e
REM ***** Draw measured signals *****
FOR i = 1 TO 640
  FOR x = 1 TO Channel
    CState = INP(HCAdr + 6) AND 240
    IF CState AND 2 ^ (3 + x) THEN
      LINE (p(x, 0), p(x, 3))-(i - 1, p(x, 1) - 50), x +
 2
      p(x, 3) = p(x, 2)
    ELSE
      LINE (p(x, 0), p(x, 3))-(i - 1, p(x, 1)), x + 2
      p(x, 3) = p(x, 1)
    END IF
    p(x, 0) = i
  NEXT x
  FOR q = 1 TO Delay:
NEXT q, i

REM ***** After each sweep: Determine what sweep mode was
 selected *****
IF meas$ = "P" THEN
  LOCATE 25, 28
  PRINT "Paused! Press any key to continue"; SPC(20);
  SLEEP
END IF
LOOP UNTIL meas$ = "S"
LOCATE 25, 20
PRINT "End of Measurement! Press any key to continue";
 SPC(10);
SLEEP
RUN

REM ***** Subroutine for F1 *****
f1:
  RUN
RETURN

REM ***** Subroutine for F2 *****
f2:
  SCREEN 0
  CLS
  END
RETURN
```

Figure 3. Listing of the GW-BASIC program

Start GW-BASIC, type the program into GW-BASIC, save it to disk, and RUN it. As shown in **Figure 4**, it will prompt you to enter a number of settings discussed above. Having done that, the display should show four horizontally running lines. Now apply a logic 1 to channel 1 by connecting the relevant input to the +5 V supply on the interface board. If everything works, the channel 1 trace should respond by shifting to the 'high' position.

The instrument is then ready for use. Remember, its inputs are suitable for connection to 5-volt digital logic only. In practice, that covers most, if not all, of today's circuits using TTL logic, as well as many CMOS and HCMOS applications. (970042)

4

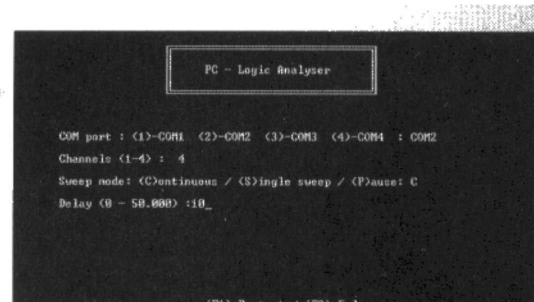


Figure 4. The welcome screen with the analyser setting prompts.

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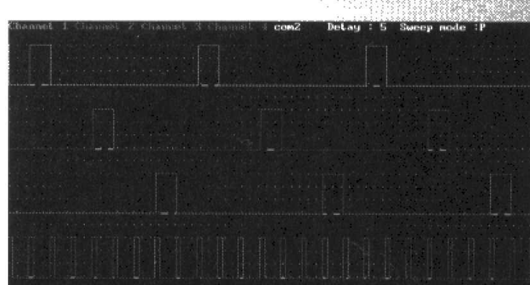


Figure 5. Example of a timing diagram supplied by the logic analyser on a PC screen (note: screen-dump converted from colour to monochrome).

using the p-i-n diode

The p-i-n (or PIN) diode is a semiconductor diode that contains a region of almost intrinsic (i-type) semiconductor between the p-type and n-type regions. The depletion layer associated with the p-n junction is entirely contained within the i-type region in the p-i-n structure. At low signal frequencies the diode behaves similarly to a normal p-n junction, but at high frequencies it exhibits a variable resistance. The p-i-n diode is used extensively as a modulator and switch in microwave systems.

By Joseph J. Carr, BSc, MSEE

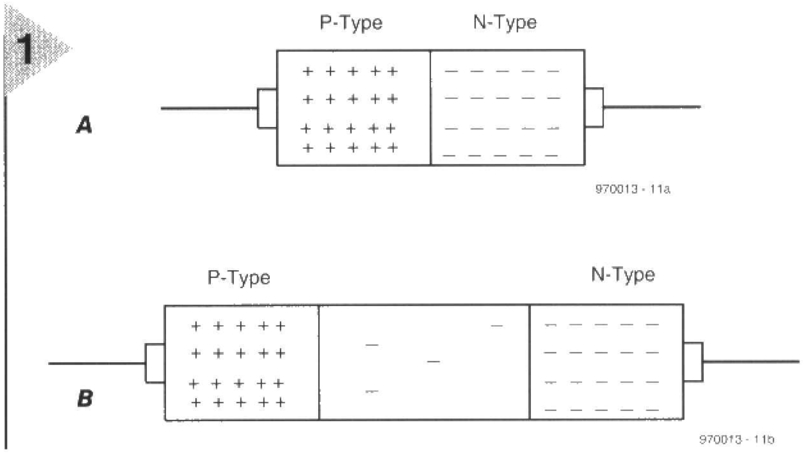


Figure 1. (A) PN junction diode; B) P-I-N diode.

Let us consider some of the applications of the p-i-n diode. Most modern radio transceivers (i.e. "transmitter–receivers") use "relayless" switching to go back and forth between the *receive* and *transmit* states. Relayless switching is usually done with p-i-n diodes. Receiver i.f. filters and front-end bandpass filters are selected with a front panel switch that handle only direct current. How? Again, p-i-n diodes. These interesting little components allow us to do switching at r.f., i.f. and audio frequencies without routeing the signals themselves all over the cabinet. In this article we will see how these circuits work.

The p-i-n diode is different from the standard p-n junction diode (see Fig. 1A). It has an insulating ('intrinsic', hence the 'i' in 'p-i-n) region between the p- and n-type material (Fig. 1B). It is therefore a multiregion semiconductor device despite having only two electrodes. The i-region is not really a true semiconductor insulator, but rather is a very lightly doped n-type region. It is called an 'intrinsic' region because it has very few charge carriers to support the flow of an electrical current.

When a forward bias potential is applied to the p-i-n diode, charge carriers are injected into the i-region from both n- and p-regions. But the lightly-doped design of the intrinsic region is such that the n- and p-type charge carriers don't immediately recombine (as in p-n junction diodes). There is always a delay period for recombination. Because of this delay phenomenon, there is always a small but finite number of carriers in the i-region that are uncombined. As a result, the resistivity of the i-region is very low.

One application that results from the delay of signals passing across the intrinsic region is that the p-i-n diode can be used as an r.f. phase shifter. In some microwave antennas phase shifting is accomplished by the use of one or more p-i-n diodes in series with the signal line. Although there are other forms of r.f. phase shifter usable at those frequencies, the p-i-n diode remains popular.

Several styles of package are used for p-i-n diodes at small signal power levels. Most of these will be familiar to most readers, but some are probably recognized only by people with some experience in u.h.f. and up switching circuits. The NTE-553 and ECG-553 p-i-n diodes will dissipate 200 mW, and use the standard cylindrical package style. The NTE-555 and ECG-555 devices, on the other hand, use the u.h.f. flat package style and can dissipate 400 mW. I used these diodes for the experiments performed to write this article because they are service shop replacement lines, and both ECG and NTE are widely distributed in local parts stores. An alternative that might be harder to come by is the MPN3404, which uses a TO-92 plastic package.

Radio frequency signals can pass through the p-i-n device, and in fact

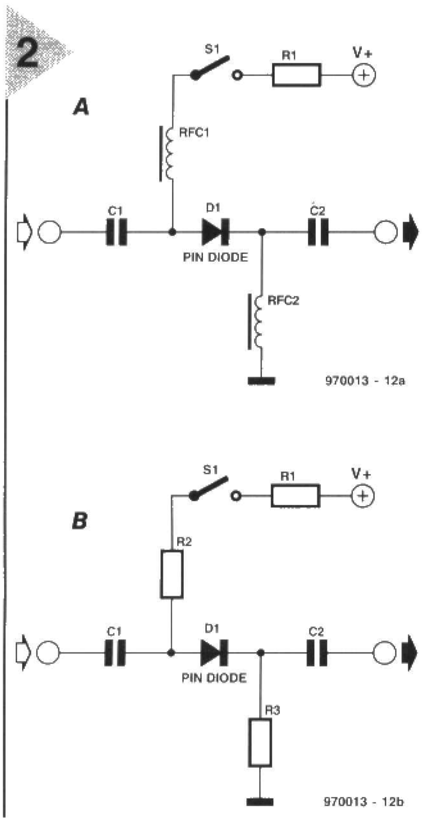


Figure 2. Series p-i-n diode switch circuits: (A) RF choke loaded; (B) resistor loaded.

see it in some circumstances as merely a parallel plate capacitor. We can use p-i-n diodes as electronic switches for r.f. signals, and as an r.f. delay line or phase-shifter, or as an amplitude modulator.

P-I-N DIODE SWITCH CIRCUITS

P-I-N diodes can be used as switches in either series or parallel modes. **Figure 2** shows two similar switch circuits. In the circuit of Figure. 2A the diode (D_1) is placed in series with the signal line. When the diode is turned on, the signal path has a low resistance, and when the diode is turned off it has a very high resistance (thus providing the switching action). When switch S_1 is open, the diode is unbiased so the circuit is open by virtue of the very high series resistance. But when S_1 is closed, the diode is forward biased and the signal path is now a low resistance. The ratio of off/on resistances provides a measure of the isolation provided by the circuit. A pair of radio frequency chokes (RFC_1 and RFC_2) are used to provide a high impedance to r.f. signals, while offering low d.c. resistance.

Figure 2B is similar to Figure 2A except that the r.f. chokes are deleted, and a resistor is added. **Figure 3** shows a test that I performed on the circuit of Figure 2B using a 455 kHz i.f. signal (the 'scope was set to show only a few cycles of the 455 kHz). The upper trace in Figure. 3A shows the input signal and the lower trace the output signal. The amplitude of the nearly unattenuated output signal is 1,200 mV peak-to-peak. The trace in Figure. 3B shows the same signals when the switch open (i.e. +12 V d.c. disconnected), but with the oscilloscope set to the same level. Increasing the sensitivity of the 'scope showed a level of 12 mV getting through. This means that this simplest circuit provides a 100:1 on/off ratio, which is 40 dB of isolation. [Note: for this experiment the ECG-555 and NTE-555 hot carrier p-i-n diodes were used].

Figure 4 shows the circuit for a shunt p-i-n diode switch. In this case, the diode is placed across the signal line, rather than in series with it. When the diode is turned off, the resistance across the signal path is high, so operation of the circuit is unimpeded. But when the diode is turned on (S_1 closed) a near-short-circuit is placed across the line. This type of circuit is turned off when the diode is forward biased. This action is in contrast to the series switch in which a forward biased diode is used to turn the circuit on.

A combination series-shunt circuit is shown in **Figure 5**. In this circuit, D_1 and D_2 are placed in series with the signal line, while D_3 is in parallel with the line. D_1 and D_2 will turn on with a positive potential applied, while D_3 turns on when a negative potential is applied. When switch S_1 is in the lower position, a positive potential is applied to the junction of the three diodes. As a result, D_1 and D_2 are forward biased and thus take on a low resistance. At the same time, D_3 is hard reverse biased, so has a very high resistance. Signal is passed from input to output essentially unimpeded (most p-i-n diodes have a very low series resistance).

But when S_1 is in the upper position, the opposite situation obtains. In this case, the applied potential is negative so D_1-D_2 are reverse biased (and take on a high series resistance), while D_3 is forward biased (and takes on a low series resistance). This circuit action creates a tremendous attenuation of the signal between input and output.

OTHER P-I-N DIODE APPLICATIONS

When used as a switch, p-i-n diodes can be used to switch devices such as attenuators, filters and amplifiers in and out of the circuit. It has become standard practice in modern radio equipment to switch d.c. voltages to bias p-i-n diodes rather than

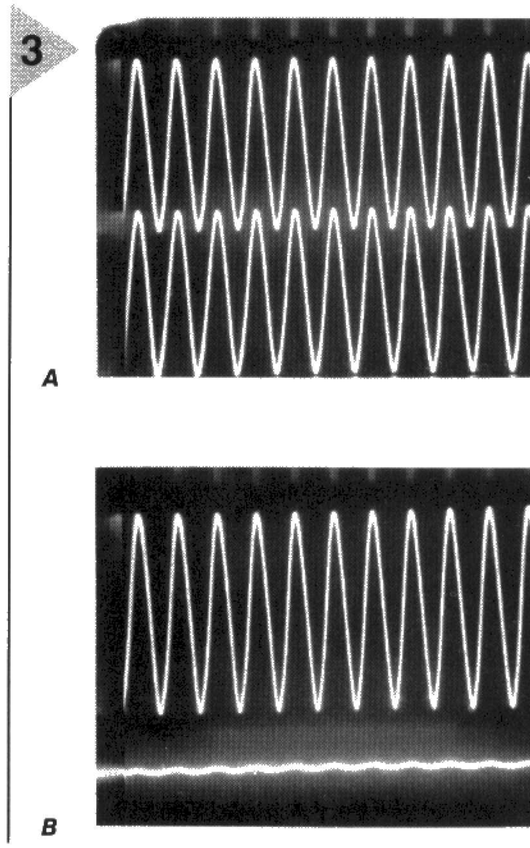


Figure 3. Switched and unswitched input/output waveforms.

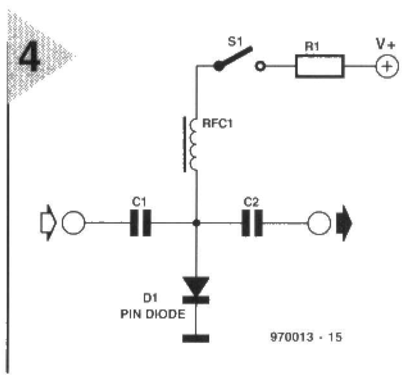
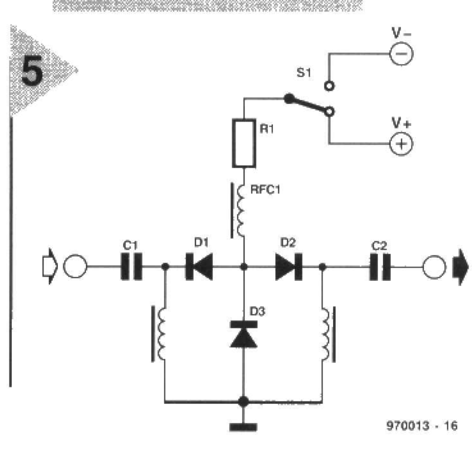


Figure 4. Shunt switch circuit.

Figure 5. Series-shunt switch circuit.



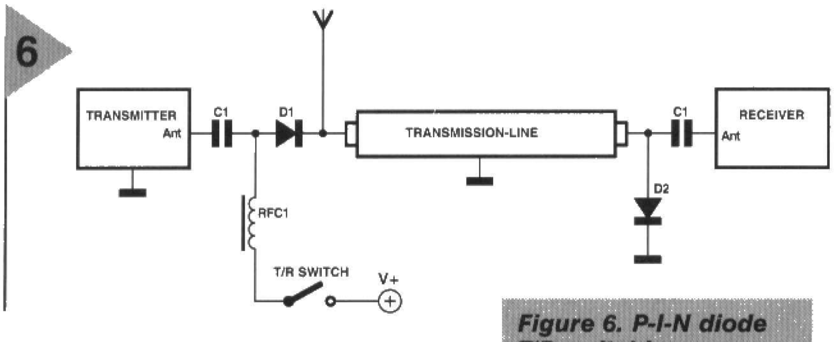


Figure 6. P-I-N diode T/R switching.

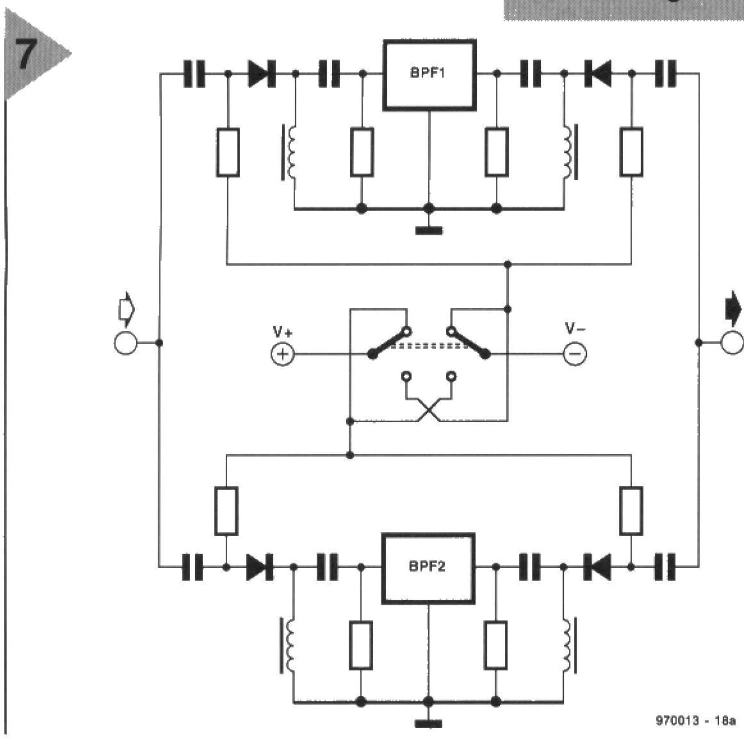


Figure 7. IF bandpass filter switching.

directly switch r.f./i.f. signals. In some cases, the p-i-n diode can be used to simply short out the transmission path to bypass the device.

The p-i-n diode will also work as an amplitude modulator. In this application, a p-i-n diode is connected across a transmission line, or inserted into one end of a piece of microwave waveguide. The audio modulating voltage is applied through an r.f. choke to the p-i-n diode. When a c.w. signal is applied to the transmission line, the varying resistance of the p-i-n diode causes the signal to be amplitude modulated.

Another application is shown in **Figure 6**. Here we have a pair of p-i-n diodes used as a transmit-receive (TR) switch in a radio transmitter; models from low-h.f. to microwave use this technique. Where you see a so-called 'relayless TR switch', it is almost certain that a p-i-n diode network such as Figure 6 is in use. When switch S_1 is open, diodes D_1 and D_2 are unbiased, so present a high impedance to the signal. Diode D_1 is in series with the transmitter signal, so blocks it from reaching the antenna; diode D_2, on the other hand, is across the receiver input so does not attenuate the receiver input signal at all. But when switch S_1 is closed, the opposite situation occurs: both D_1 and D_2 are now forward biased. Diode D_1 is now a low resistance in series with the transmitter output signal, so the transmitter is effectively connected to the antenna. Diode D_2 is also a low resistance, and is across the receiver input so causes it to short out.

Figure 7 shows how multiple i.f. bandpass filters are selected with only d.c. being routed around the cabinet between circuitry and front panel. When the switch is in the position shown, V+ is fed to filter no. 2 diodes and V− to those of BPF1; so filter no. 2 is activated and BPF1 is blocked. When the switch is in the opposite position, the alternate filter is turned on. This same arrangement can be used in the front-end of the receiver, or the local oscillator, to select *LC* components for different bands.

Another filter selection method is shown in **Figure 8.** This circuit is a partial representation of the front-end circuitry for the Heathkit SW-7800 general coverage shortwave receiver.

The circuit of Figure 8 is shown using a switch (S_1) to apply or remove the +12 V d.c. bias potential on the diodes, but in the actual receiver this potential is digitally controlled. The digital logic elements sense which of thirty bands are being used, and selects the input r.f. filter accordingly.

P-I-N DIODE ATTENUATORS

Another application for p-i-n diodes is as a voltage-variable attenuator in r.f. circuits. Because of its variable resistance characteristic, the p-i-n diode can be used in a variety of attenuator circuits. One of the simplest is the shunt attenuator of **Figure 9**. The p-i-n diode acts like an electronically variable resistor. The resistance across the diode's terminals is a function of the applied bias voltage. This voltage, hence the degree of attenuation of the r.f. signal, is proportional to the setting of potentiometer R_1. The series resistor (R_2) is used to limit the current when the diode is forward biased. This step is necessary because the diode becomes a very low resistance when a certain rather low potential is exceeded. This circuit is used as an r.f. gain control on some modern receivers. [970013]

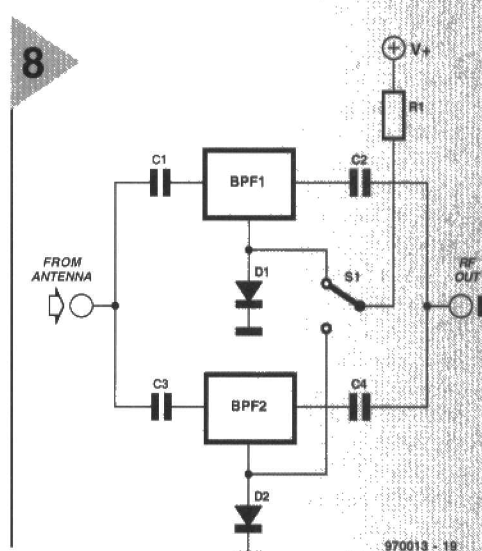
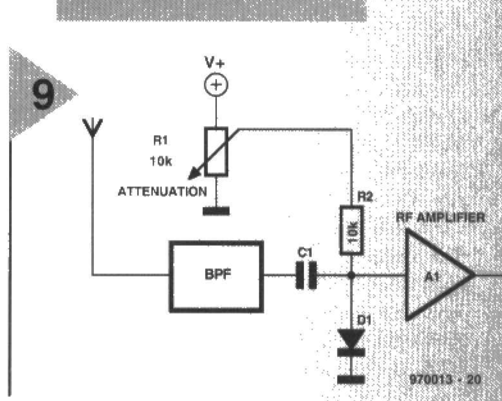
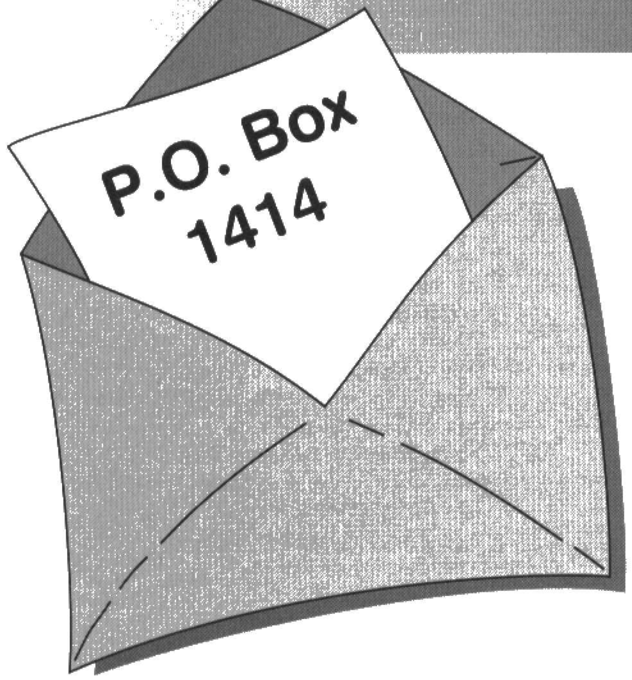


Figure 8. Front-end filter switching.

Figure 9. Simple variable r.f. attenuator circuit.





underlines on cd-rom

Dear Editor—I was surprised to note on the CD-ROM with winning programs of the software competition that all hyphens in the file names have been altered into underlines.(US: underscores). I refer in particular to the programmable remote control – MiniZap – to be found in directory NL\21.

The underlining does not pose a problem as far as the EXE files and the device drivers are concerned, but when XP-ZAP.EXE (altered into XP_ZAP.EXE) is started, the program looks for ini-file XP-ZAP.EXE, which it cannot find because this is now called XP_ZAP.INI. This means that the preferred settings of the user can no longer be loaded.

Iit is not clear to me why this alteration was found necessary: I have never had problems with hyphens in file name, and it occurred to me that it would be useful to other readers to write to you. Users may note that the problems can be resolved easily by renaming the file name XP_ZAP.INI to XP-ZAP.INI.

M.M.

There are several CD-ROM formats; most PCs use the ISO-9660 standard. In this standard a number of ASCII symbols cannot be used in file names and one of these is the hyphen. For the production of our CD-ROMs ISO-9660 is used and this means that during the writing of the disk all hyphens are automatically converted into underlines. It is possible to circumvent this conversion (and this is, indeed, often done nowadays), but the disk would then no longer meet the standard. As you have already correctly pointed out, the remedy is simple: copy all files to a directory on the hard disk and replace the underlines in the file names by a hyphen. All will then work 'normally' again.

remote control

(April 1989)

Dear Editor—I have been looking for the Elektor Electronics issue which contained a project for a remote control extension. This is for use to control a VCR or TV receiver from a room adjacent to the one where the equipment is located.

P.H.

This project appeared in our April 1989 issue (p. 31). Since this is obsolescent, a new design for such an extension will be published in a future issue of this magazine.

motor controller

(February 1997)

Dear Editor—Your February 1997 issue contains an article describing a 'Motor controller for R/C models'.

The data for this circuit state that the controller is suitable for operation from supply voltages of 6–10 V. My question is: can the controller be used with a 12 V supply or do I have to alter a few components?

P.K.

No problem: the controller can work from 12 V. The processor, IC_1, operates from a regulated +5 V line, irrespective of the input supply voltage. Nevertheless, we recommend an absolute limit of 15 V. What is more important, however, is the current drawn by the motor: this must not exceed 40 A to ensure that the ratings of the MOSFETs are not exceeded.

magnetic field meter

(January 1997)

Dear Editor—When I connect the 'Magnetic-field meter' to my computer and start the associated program, I get the message when using DOS: 'interface not found'; when I use Windows the program does not start at all. I have carefully checked the completed board but cannot find anything wrong.

C.S.

We have checked your board with several of our computers and have experienced no problems: all worked well. It is probable that the problem lies in the printer connection of your computer. In modern computers, a choice may be made in the BIOS between standard mode, EPP mode and ECP mode for the printer port. In many mother boards the standard setting is EPP+ECP. When in that case the ECP or the EPP+ECP mode is selected, the circuit does not work. You will therefore have to check the BIOS settings and make sure that the EPP mode for the printer port is selected.

pc sound card as af analyser

(March 1996)

Dear Editor—The 'PC soundcard as AF analyser' uses the sound card present in the computer. To what degree does the quality of this card affect the test results?

I have a simple, inexpensive soundcard and have been advised that the output of this card contains steep-skirted filters to suppress any interference causes by the PC power supply or the card itself. This is manifested by the fact that when I use a tone generator program the peak values of the high-frequency signals start dropping from about 6 kHz. Are such filters also used on a card like the Soundblaster 16?

On asking several dealers trading in such cards, I could not get the right information because the specifications supplied with the card do not include this. Cards from Terradec, I understand, are superior as regards the audio specification to SB16 cards from Creative Labs. Can you give me any advice as to which to obtain?

The second question I have is: what can be done to suppress interference and noise signals inside the computer? For instance, does whole or partial screening of the soundcard make sense?

J.W.

There are, indeed, appreciable differences in quality between the various soundcards on the market. Inexpensive soundcards often have a poor frequency response which rolls off very steeply at both sides of the band. If reliable measurements are to be carried out, the soundcard used must have a wide, linear frequency response and, if at all affordable, low distortion. We cannot advise on which to buy, but suggest that you glean the tests on soundcards that are carried out from time to time by various computer magazines.

Soundblaster cards are generally of good to very good quality and, therefore, normally a good buy. What is important when such a card is used in combination with test software is the protocol by which the card provides its drive power. Many Soundblaster-compatible cards simulate (in DOS) an old 8-bit Soundblaster card. Test software running under DOS that require 16-bit precision cannot cope with that. So, make sure that you use a genuine Soundblaster card (or an OEM product with a Vibra chip).

Screening the card is a good means of excluding external stray interference and noise. It does not reduce such interference on the supply lines, however. These can only be avoided by locating the card outside the computer and give it its own power supply.

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CORRECTIONS & UPDATES

Dark-room timer

(October 1996 - 960086)

The proposed stop scale for the timer (Figure 5) should be turned around because the delay time increases when the control is turned clockwise. Also, the value of C_1 is incorrectly given as 1 μF in the parts list, whereas the correct value is 1.8 μF as shown in the circuit diagram.

Matchbox BASIC computer as data logger

(September 1996 - 960065)

Owing to a text conversion error, all underscores in the names of variables have dropped out of the program listing shown in Figure 4. The correct variable names are LOG_MAX, START_LOG, COM_CHR, LOG_RAM, LOG_DATA, READ_MAXIM and DUMP_PTR.

Also, The compiler is unable to process the line

WHILE DUMP_PTRG MAX DO

which is best replaced by

WHILE DUMP_PTR GMAX DO

Motor controller for R/C models

(February 1997 - 960095)

The text incorrectly states that D_1 and D_2 are not required for unidirectional mode. This should be D_1 and T_1. The penultimate paragraph on page 17 and the first complete paragraph in the right-hand column on page 18 should be amended accordingly.

68HC11 Emulator

(February 1997 - 970008)

The correct name of the Talker for use with a 5 MHz crystal is TKAXTS_B00 (inset *Talkers for use with the emulator*, page 25).

Contrary to what is stated under the *Applications examples, FAQs* heading, the Hi-Tech compiler is not in the M11DISK\UTILI\ directory. Users having access to version 7 of this compiler may, however, use SYMWICE.EXE to build a small high-level debugger. Likewise, the SYMWICE.C file may help users of other compilers or earlier versions of the Hi-Tech compiler. SYMWICE.EXE also works for the WICE emulator.

The text *In the latter case, ports B and C* ... (page 23, third line from the bottom) should be corrected to read: *In both cases, ports B and C* ....

The TL7705 will switch at a low-supply voltage of 4.5 V, not 3.6 V as stated at the top of the right-hand column on page 24. The reference voltage is calculated from: $V_{ref}\,(R_2+R_1)/R_1 = 2.53\times17.8/10 = 4.5$ V.

Simple inductance meter

(February 1997 - 970009)

In the circuit diagram on page 32, diodes D_2 through D_9 should be connected to K_1 pins 2 through 9, not pins 1 through 8. The layout of the printed circuit board is not affected.

Copybit inverter

(January 1996 - 950104)

The input stage around gate IC_{1a} may start to oscillate when the optimum sensitivity is reached by adjusting preset P_1. This spurious oscillation may upset the normal operation of the circuit. The problem is remedied by fitting a 47μF/25V electrolytic capacitor in parallel with C_2 at the track side of the board. The relevant connections should be kept as short as possible.

The settings of the three presets on the board are determined to a large extent by the quality of the applied S/PDIF signal. The settings are, therefore, dependent on the digital signal source.

lcr meter - part 1

(April 1997 - 970028/1)

Some unfortunate errors have crept into some text and the box on p. 32.

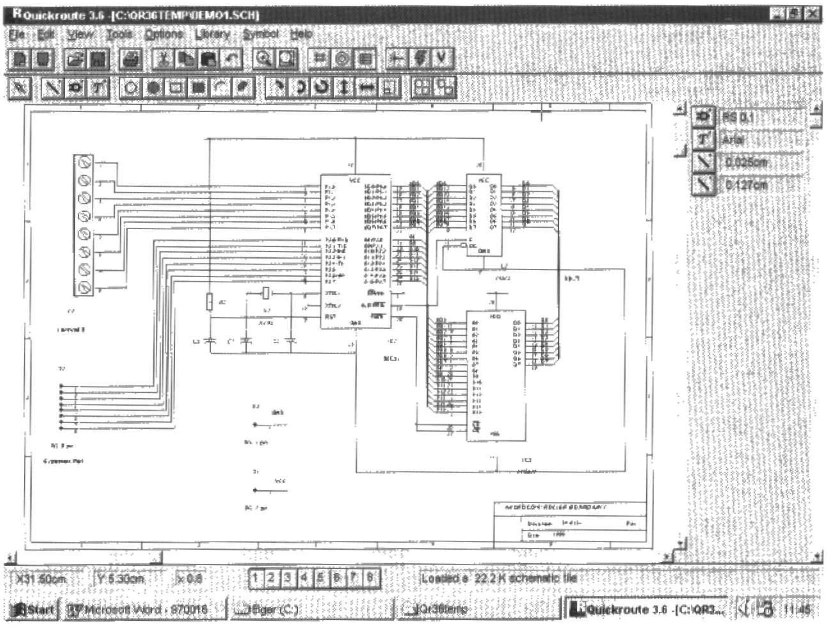
In the 8th line, centre column, $10^2/10^5$ should read $10^2//10^5$.

Z_{out} in the 9th and 12th lines should read Z_{dot} (where dot is the device on test).

In the formulas in the box, $2ni$ should read $2\pi i$ in all five cases. The first formula should start: $U_1\cos\varphi_1 =$, and the second formula: $U_1\sin\varphi_1$.

Quickroute 3.6 PRO+

Quickroute is a modern, powerful and easy to use program for the design of circuit diagrams and PCB layouts. The program, which is stored on disk as a compressed file, runs on any PC with a 386 processor or better, at least 4 MB RAM (8 MB recommended) and 5 MB of hard disk space. The program is Windows 3.1 or 95 hosted. This article discusses the PRO+ version of Quickroute, which is aimed at (semi-)professional users, offering an auto-router and file import and export functions. New for Quickroute 3.6 PRO+ is the ability to accept plug-in modules, the first of which were launched recently.



Quickroute consists of two program modules, one for drawing circuit diagrams ('schematic capture') and one for designing printed circuit boards. The **schematic capture** program is divided into four sections (see above). The *menu bar* at the top of the screen gives access to a large number of tools and functions, which may be selected by mouse clicks or keyboard shortcuts. Many of the functions for editing and arranging objects, as well as the obligatory file functions like New, Open, Save and so on, are integrated in the *symbol bar* which appears directly below the menu bar. The two bars at the top of the screen provide a very easy-going user interface. The status list appears at the bottom of the screen, indicating the cursor position, magnification, and the active circuit layer. It also shows condensed information on the meaning of the symbol or function at which the cursor is pointed. At the right of the screen is the active *library*, which indicates frequently used objects like component symbols, connections or texts. The largest part of the screen is occupied by a window in which the circuit diagram is created. This area has the usual vertical and horizontal scroll bars. Furthermore, extensive options are available for moving and displaying the working area.

Quickroute includes a range of symbol libraries covering more or less standard electronic components, and these may be extended with your own designs. The PRO+ review copy we received came with two supplementary plug-in library packs: *CMOS & SMT* and *TTL & ADC/DAC*. Further packs may become available from Quickroute, and (prospective) users are advised to check the Quickroute web site at http://www.quickroute.co.uk for availability of new additions and releases.

The component symbols are picked from symbol selection windows, dragged and placed onto the 'construction area', moved if necessary, copied or deleted, and then linked to a network of connections. All objects have attributes indicating position, object size, type, value and other salient details. To edit an attribute you simply double-click on the relevant symbol. This opens a window in which the necessary modifications may be made.

The component picking phase may be shortened by moving frequently used symbols, along with their attributes, into the working library, from which they are instantly available for use in circuit diagrams. Finished schematics and parts lists may be printed (optionally in HPGL or Postscript format) or saved as a bitmap file. Exporting to WMF or DXF file format is also possible. A very interesting feature of Quickroute 3.6 PRO+ is its ability to generate Tango, Spice or SpiceAge netlists, allowing these programs to simulate or test a circuit. A link to *Electronics Workbench* is also provided.

Having drawn the schematic, your next task is to **design a printed circuit board**. This is done in a window whose structure and operation closely resembles the one used for drawing the circuit diagram. The working area is displayed as an inverted image, while the library now contains component shapes instead of circuit diagram symbols, and a few extra icons in the symbol list. For the rest, everything remains largely as before.

Several options are available for the design of a PCB layout: using *manual design* the mouse is used to pick PCB symbols from the (working) library and drag them onto the working area. The process of placing solder pads, copper tracks, symbols and text onto one or more PCB layers is basically identical to assembling the circuit diagram. The result of the manual design work is a PCB layout (consisting of multiple layers) which may be printed, saved or exported in different file formats. The second option (illustration at the top of this page) is to have the program produce a *rats-nest*. In this process, the schematic symbols are replaced by component shapes (PCB symbols), and all connections between the symbols are automatically made. The operation is initiated by clicking on the rats-nest symbol in the schematic capture program, whereupon the active schematic is analyzed and replaced by a corresponding network in the PCB layout program. Next, you arrange the network symbols until they have the desired position on the board, striving, of course, to achieve the lowest possible number of crossed rat lines. After this re-positioning operation, Quickroute offers an automatic comparison of schematic against PCB layout. In PRO+, this connectivity check is pretty fast and easily controlled.

Quickroute offers manual as well as automatic routing of the rats-nest links. If you select *manual routing*, a rat line linking two or more points is replaced by a PCB track whose course on the board is determined by the user. The type of PCB track is selected from the Options/Track Type menu. Once all rat lines have been replaced by tracks, the routing is checked.

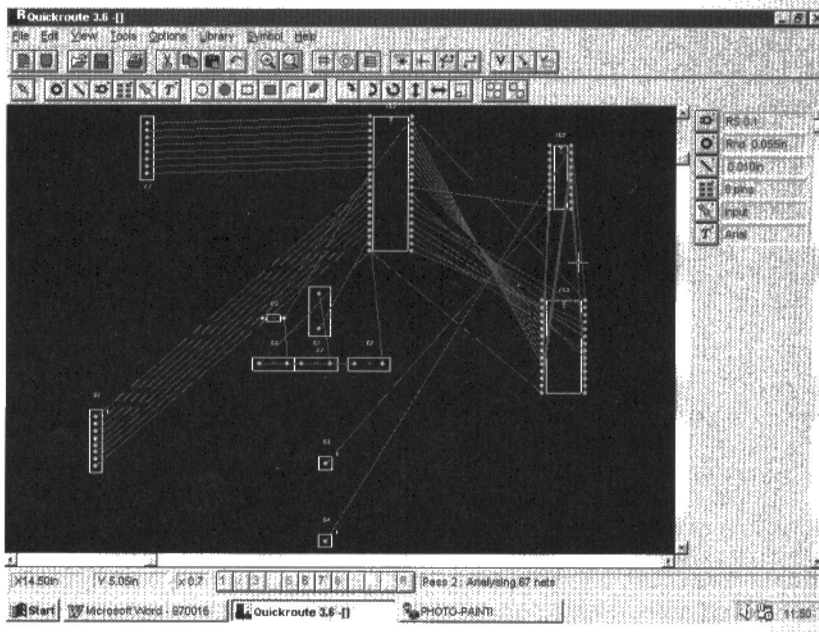
The PRO+ program offers a powerful auto-router, RouteASSIST, the results of which may be seen in the screendump at the bottom of this page. The auto-router operates on any number of layers, using a time limit, mixed track types, through-contacts and other options, all of which are executed at high speed. An incomplete automatic routing operation may be terminated manually, or modified. RouteASSIST even allows individual PCB tracks to be automatically routed.

As soon as a design has been translated into a corresponding network of PCB tracks, using manual or automatic routing, Quickroute runs an automatic check on the PCB track distances, and highlights all tracks and solder pads which violate the design rules set up by the user.

Further interesting and useful functions of the PRO+ software include:

Forward Annotation

When comparing the circuit diagram with the actual PCB layout, PRO+ not only highlights differences, but also indicates which corrections which have to be made to a PCB as a result of changes to the schematic. The process is also called *Engineering Change*.



Copper Fill

Large regions of filled copper are not only useful on RF boards; they are often applied wherever there is a requirement for additional screening of circuit sections. Quickroute PRO+ is capable of automatically filling the free regions of a board surface with a copper layer, and still observe the minimum distance to be maintained to copper tracks and solder pads.

Vectorisation

Quickroute PRO+ is capable of replacing filled polygon shapes and other objects by equivalent elements consisting of copper track segments. This is not only useful with the automatic checking of minimum track distances, but also when exporting a layout in a file format that does not support certain object types.

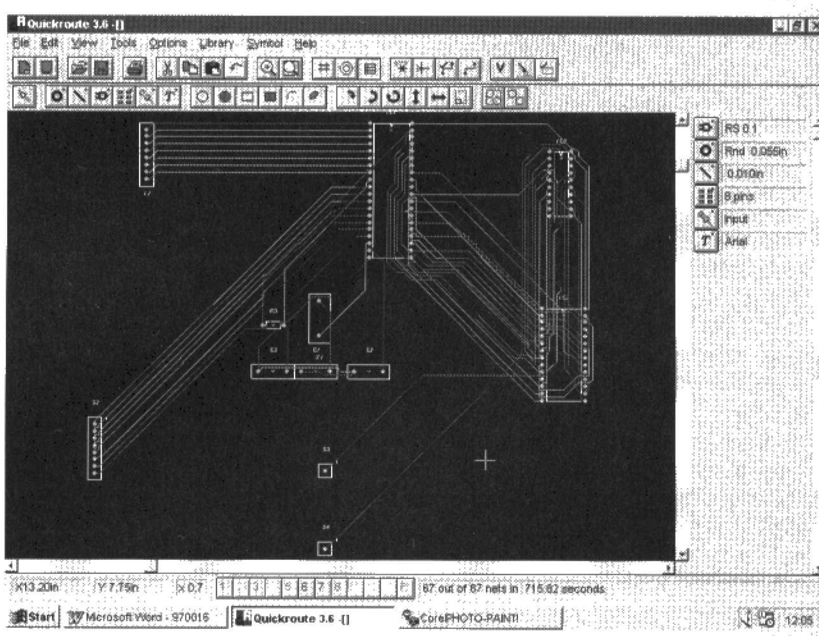
Import/Export

In addition to the standard formats such as Windows BMP, PRO+ supports a large number of file types including Gerber, NC-Drill, DXF, Tango and WMF (Windows Metafile).

Finally, we should mention that Quickroute Systems recently launched a plug-in module called SMARTRoute 1.0. Priced at £149 plus VAT, this module offers an extremely powerful 32-bit auto-router extension for Quickroute.

(974050)

Quickroute 3.6 PRO+ costs £399, and is available from Quickroute Systems Ltd., Regent House, Heaton Lane, Stockport, Cheshire SK4 1BS. Tel. (0161) 476 0202, fax (0161) 476 0505. E-mail info@quicksys.demon.co.uk.



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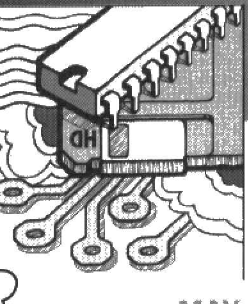

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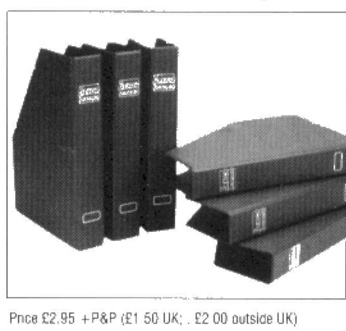
- Software on disk	966001-1	26.00	52.00
MARCH 1996			
Houseplant Buzzer (4 on 1 board)	950118-1	10.00	20.00
PIC-Controlled RDS Decoder:			
- PCB + PIC (966505-1)	960050-C	27.50	55.00
- PIC 16C84	966505-1	22.75	45.50
FEBRUARY 1996			
SIMM tester:			
- PCB + EPROM (966503-1)	960039-C	28.25	56.50
- EPROM	966503-1	10.25	20.50
I²C Interface for Centronics port:			
- PCB + disk (946202-1)	950063-C	20.25	40.50
- control software on disk	946202-1	12.25	24.50
Passive VU meter	950124-1	8.00	16.00
Icy Roads Warning	960029-1	6.00	12.00
JANUARY 1996			
SECAM-to-PAL Converter	*950078-2*	*29.00*	*58.00*
Copybit Inverter:			
- PCB + MACH/GAL	950104-C	44.00	88.00
- MACH/GAL	956513-1	35.25	70.50
Passive Component Tester			
- PCB	960032-1	13.75	27.50
- Front panel foil		Not available	
DECEMBER 1995			
3.3-15V Power Supply	950106-1	9.25	18.50
Practice Amplifier for Guitars			
PCB + front panel foil	950016-C	30.50	61.00
PCB only	950016-1	17.25	34.50
Front panel foil only	950016-F	13.75	27.50
Smart Transistor Tester:			
- PCB + PIC (956502-1)	950114-C	44.25	88.50
- PIC 16C71	956502-1	35.50	71.00
Micro PLC System:			
- PCB + 87C750/51 + disk	950093-C	44.50	89.00
- 87C750/51	956514-1	24.50	49.00
- control software on disk	956016-1	10.00	20.00
Active potentiometer	954099-1	9.50	19.00
Descaler	954080-1	5.75	11.50
Active probe	954093-1	8.00	16.00
Two-way PC-Fax Interface	954033	11.75	23.50
NOVEMBER 1995			
PIP Processor:			
- PCB + 87C51 (956505-1)	950078-C	54.75	109.50
- 87C51	956505-1	30.75	61.50
FM noise squelch	950089-1	10.75	21.50
PA 300 power amplifier	950092-1	19.75	39.50
Jogging LED	950112-1	7.00	14.00
Oscilloscope prescaler	950115-1	27.75	55.50
OCTOBER 1995			
MatchBox BASIC computer:			
- PCB, 87C51 disk and Quick Reference Card	950011-C	59.25	118.50
- 87C51	956508-1	43.50	87.00
- Course diskette (DOS)	956009-1	11.50	23.00
- Quick Reference Card	950011-P	3.25	6.50
SEPTEMBER 1995			

Article title or item	Order code	Price £	US$
Hi-Fi headphone amplifier	950064-1	5.00	10.00
Dongle safe:			
- PCB	950069-1	12.75	25.50
- GAL IC2 (20V8)	956511-1	10.00	20.00
- GAL IC6 (22V10)	956512-1	11.75	23.50
HexFET power amp upgrade:			
- amplifier PCB	930102	12.75	25.50
Copybit eliminator update:			
- PCB + MACH (956504-1)	950084-C	40.50	81.00
- MACH IC	956504-1	36.50	73.00
RF tone-dip oscillator	950095-1	5.25	10.50
JULY/AUGUST 1995			
Simple RF function generator	950023-1	7.50	15.00
Alkali/Manganese battery charger	950065-1	6.75	13.50
Fast charger for NiCd batteries:			
- PCB + ST62T20 (956509-1)	950076-C	22.75	45.50
- ST62T20	956509-1	14.75	29.50
Simple I/O card	954074-1	11.50	23.00
JUNE 1995			
Function generator:			
- PCB	950068-1	29.50	59.00
- Front panel foil	950068-F	17.75	35.50
Electronic sandglass:			
- PCB + 87C751 (946647-1)	950052-C	26.25	52.50
- 87C751	946647-1	17.75	35.50
Auto light control	950050-1	4.75	9.50
VGA distribution amplifier	950017-1	10.00	20.00
MAY 1995			
MIDI analyser:			
- PCB + EPROM (956507-1)	940020-C	34.25	68.50
- EPROM	956507-1	16.75	33.50
Programmer for 87/89C51 series Flash controllers:			
- PCB + EPROM (956644-1)	950003-C	26.50	53.00
- EPROM	946644-1	14.50	29.00
Programmable sine wave generator:			
- PCB + disk (956005-1)	950004-C	19.50	39.00
- control software on disk	956005-1	12.25	24.50
NiCd battery-quality tester:			
- PCB + ST62T15 (956506-1)	950051-C	25.25	50.50
- ST62T15	956506-1	18.25	36.50
APRIL 1995			
Sun blind control	950035-1	9.25	18.50
Function generator:			
- PCB + front panel foil	950044-C	21.75	43.50
- PCB	950044-1	11.00	22.00
- Front panel foil	950044-F	12.50	25.00
Stepper motor control:			
- PCB + 8751 + disk	950038-C	50.75	101.50
- 8751	956503-1	35.25	70.50
- test program on PC disk	956004-2	3.75	7.50
MARCH 1995			
Telephone-controlled mains switch:			
- PCB + PIC (946642-1)	950010-C	22.00	44.00
- PIC 16C54	946642-1	17.50	35.00
DSP function generator:			
- PCB + disk (956001-1) + EPROM (956501-1)	950014-C	49.00	98.00
- EPROM 27C512	956501-1	13.25	26.50
- software on IBM PC disk	956001-1	18.50	37.00
- Windows program manual	950014-P	7.50	15.00
TDA1560Q car audio amplifier	950024-1	9.50	19.00
FEBRUARY 1995			
Automatic lighting timer	*940098-1*	*10.75*	*21.50*
Infrared dimmer	940109-1	9.75	19.50
Light-effects generator	940100-1	6.50	13.00
Surround sound processor	950012-1	18.75	37.50
Induction motor governor	940095-1	7.50	15.00
JANUARY 1995			
Mini Audio DAC	940099-1	14.75	29.50
1-to-3-phase converter:			
- PCB + GAL + EPROM	940077-C	52.75	105.50
- GAL	946640-1	12.25	24.40
- EPROM	946640-2	15.75	31.50
P.O.S.T. diagnostic card:			
- PCB + GALs (946639-1/2)	950008-C	29.25	58.50
- GAL-1	946639-1	11.00	22.00
- GAL-2	946639-2	13.00	26.00
Self-loading EEPROM type			

For availability of older items, please contact our Dorchester office.

Elektor Electronics slipcase



Price £2.95 + P&P (£1.50 UK; . £2.00 outside UK)